07:00–18:00 Registration, *Concourse Level*

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

08:00–10:00 FM1A • Quantum Optomechanics & Transduction
Presider: Gabriel Molina Terriza; Centro de Fisica de Materiales, Spain

FM1A.1 • 08:00
Ultralow Dissipation Mechanical Resonators for Quantum Optomechanics, Nils Johan Engelsen[1], Sergey A. Fedorov[1], Amir H. Ghadimi[1], Mohammad J. Bereyhi[1], Alberto Beccari[1], Ryan Schilling[1], Dalziel J. Wilson[2], Tobias J. Kippenberg[1]; [1]*Ecole Polytechnique Fédérale de Lausanne, Switzerland;* [2]*IBM Research — Zürich, Switzerland.* We demonstrate dissipation dilution engineering techniques for ultralow dissipation mechanical resonators. The Si_3N_4 nanobeams show quality factors (Q) as high as 800 million and $Q\times f$ exceeding 10^{15} Hz—both records at room temperature.

FM1A.2 • 08:15
Dynamical gauge fields for phonons in an optomechanical system, Javier Del Pino[1], John P. Mathew[1], Ewold Verhagen[1]; [1]*AMOLF, Netherlands.* We demonstrate a synthetic gauge field for phonon transport in a nano-optomechanical platform. Employing time-modulated radiation pressure forces, we evidence nonreciprocal nanomechanical phase transfer. We show how this enables new classes of phononic topological insulators.

FM1A.3 • 08:30
Quantum Measurement of a Mechanical Resonator At and Below the Standard Quantum Limit, Massimiliano Rossi[1,2], David Mason[1,2], Junxin Chen[1,2], Yeghishe Tsaturyan[1], Albert Schliesser[1,2]; [1]*Niels Bohr Inst., Denmark;* [2]*Niels Bohr Inst., Center for Hybrid Quantum Networks (Hy-Q), Denmark.* We measure mechanical displacements within 35% of the Heisenberg limit. By exploiting quantum correlations in an optomechanical system, we achieve for the first time a total sensitivity below the standard quantum limit by 1.5 dB.

08:00–10:00 FM1B • Topological Photonics I
Presider: To Be Announced

FM1B.1 • 08:00
Spin-Preserving Chiral Photonic Crystal Mirror, Behrooz Semnani[1,2], Jeremy Flannery[2], Zhenghao Ding[2], Rubayet Al Maruf[2], Michal Bajcsy[2,1]; [1]*ECE, Univ. of Waterloo, Canada;* [2]*Inst. for Quantum Computing, Canada.* We report on experimental realization of a chiral photonic-crystal structure which exhibits extreme intrinsic chira-optical activity. Formation of quasi-bound-states-in-continuum allows selective reflection of the circular polarization states of light and unconventionally preserves the handedness.

FM1B.2 • 08:15
Lossless Zero-Index Guided Modes via Bound States in the Continuum, Momchil Minkov[1], Ian Williamson[1], Meng Xiao[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* Zero-index metamaterials are sought for a number of applications, but have thus far always been associated with significant optical loss. We overcome this shortcoming by designing non-radiative zero-index modes in an all-dielectric photonic crystal slab.

FM1B.3 • 08:30
Non-Hermitian-enhanced photonic zero mode, Mingsen Pan[3,1], Han Zhao[2], Pei Miao[3,1], Stefano Longhi[4], Liang Feng[3]; [1]*Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA;* [2]*Dept. of Electrical and Systems Engineering, Univ. of Pensylvinia, USA;* [3]*Dept. of Materials Science and Engineering, Univ. of Pensylvinia, USA;* [4]*Dipartimento di Fisica, Politecnico di Milano and Istituto di Fotonica e Nanotecnologie del Consiglio Nazionale delle Ricerche, Italy.* By ultrafast heterodyne measurements of light transport dynamics in a silicon waveguide lattice, we experimentally demonstrated the existence of a zero-energy mode whose topological characteristics are enhanced by non-Hermitian quantum phase engineering.

08:00–10:00 FM1C • Novel Phenomena in Classical Nano-Optics
Presider: Mo Mojahedi; Univ. of Toronto, USA

FM1C.1 • 08:00
Brightness Theorems for Nanophotonics, Hanwen Zhang[1], Chia Wei Hsu[1], Owen Miller[1]; [1]*Yale Univ., USA.* We present nanophotonic ''brightness theorems'', a set of power-concentration bounds that generalize their ray-optical counterparts, and motivate the concept of '' wave étendue''. We show their ramifications in the design of metasurfaces and waveguide combiners.

FM1C.2 • 08:15
The Meaning and Use of Phase in Sub-wavelength Scattering, Zhean Shen[1], Aristide Dogariu[1]; [1]*Univ. of Central Florida, CREOL, USA.* We show that the influence of evanescent wave is preserved in the phase of far field as an energetic time delay during scattering. We demonstrate the capability for sub-wavelength sensing by far-field phase measurements.

FM1C.3 • 08:30
Power–Bandwidth Limits in Near-Field Nanophotonics, Owen Miller[1], Hyungki Shim[1]; [1]*Yale Univ., USA.* We find upper bounds to near-field optical response, for any material over any bandwidth. We apply this approach to CDOS, a photon-entanglement measure, and derive the first general bounds to near-field radiative heat transfer.

08:00–10:00 FM1D • Coherent Phenomena in Coupled Resonator Networks
Presider: To Be Announced

FM1D.1 • 08:00 Invited
Solving Hard Computational Problems with Coupled Lasers, Nir Davidson[1]; [1]*Weizmann Inst. of Science, Israel.* We present a new a new system of coupled lasers in a modified degenerate cavity that is used to solve difficult computational tasks.

FM1D.2 • 08:30
Mode-Dependent Coupling and Vectorial Optical Vortices in Metallic Nanolaser Arrays, Midya Parto[1], William Hayenga[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*Univ. of Central Florida, CREOL, USA.* We demonstrate both theoretically and experimentally that metallic nanolasers display different coupling behaviors depending on the vectorial electromagnetic modes within each nanocavity. Symmetric, antisymmetric, as well as vector-vortex lasing supermodes are observed in such structures.

07:00–18:00 **Registration,** *Concourse Level*

Executive Ballroom 210E

Joint

08:00–10:00
JM1E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications I

JM1E.1 • 08:00 Invited
Recent Advances in SESAM-modelocked High-power Thin Disk Lasers, Ursula Keller[1]; [1]*ETH Zurich, Switzerland.* Nonlinear refractive index of the intracavity air is a problem. We review how the negative phase shift achievable from cascaded nonlinearities can cancel the positive phase shift from air to support 210-W average output power.

JM1E.2 • 08:30 Invited
High average power ultrafast lasers: large aperture quasi-phase matched nonlinear devices, Takunori Taira[1,2], Hideki Ishizuki[1]; [1]*Inst. for Molecular Science, Japan;* [2]*Laser-Driven Electron-Acceleration Technology Group, Japan.* Large aperture (LA) quasi-phase matched (QPM) nonlinear devices have been developed for functional wavelength conversion without catastrophic damages. The LA-QPM Mg-doped LiNbO3 and Quartz offer the artificial nonlinear short pulse lasers in high power region.

Executive Ballroom 210F

CLEO: Science & Innovations

08:00–10:00
SM1F • Optical Clocks
Presider: Andre Luiten; Univ. of Adelaide, Australia

SM1F.1 • 08:00
Measuring Optical Frequency Ratios with Uncertainties Below 10^{-17} via the Boulder Atomic Clock Network, Holly F. Leopardi[1,2], Kyle Beloy[2], Martha I. Bodine[2], Toby Bothwell[3,1], Sam Brewer[2], Sarah Bromley[3,1], Jwo-Sy Chen[2], Jean-Daniel Deschênes[4], Scott A. Diddams[2,1], Robbie Fasano[1,2], Tara M. Fortier[2,1], David Hume[2], Dhruv Kedar[3,1], Colin Kennedy[3], Isaac H. Khader[2,1], David Leibrandt[2,1], Andrew Ludlow[2], Will Mcgrew[1,2], Will Milner[3,1], Nathan R. Newbury[2], Daniele Nicolodi[2], Eric Oelker[3,1], John Robinson[3,1], Stephan Schaffer[2], Jeff A. Sherman[2], Laura C. Sinclair[2], Lindsay Sonderhouse[3,1], William C. Swann[2], David Wineland[2], Jian Yao[2,1], Jun Ye[3,2], Xiaogang Zhang[2]; [1]*Univ. of Colorado Boulder, USA;* [2]*National Inst. of Standards and Technology, USA;* [3]*JILA, USA;* [4]*Octosig Consulting, Canada.* We present frequency ratio measurements for $^{27}Al^{+}$, ^{171}Yb, ^{87}Sr with total uncertainties at or below the level of $1x10^{-17}$.

SM1F.2 • 08:15
Optical frequency measurements at the 20th decimal digit, Michele Giunta[1,2], Wolfgang Hänsel[1], Matthias Lezius[1], Marc Fischer[1], Thomas Udem[2], Ronald Holzwarth[1,2]; [1]*Menlo Systems GmbH, Germany;* [2]*Max Planck Inst. of Quantum Optics, Germany.* We report on a feed-forward method for compensating phase drifts occurring in multi-branch frequency combs. Tracking the optical phase and compensating the drifts, we demonstrate comb accuracy and stability below 10^{-19} in less than 100s.

SM1F.3 • 08:30 Invited
Optical Atomic Clocks: From International Timekeeping to Gravity Potential Measurement, Helen Margolis[1], Heiner Denker[2], Christian Voigt[2,4], Ludger Timmen[2], Jacopo Grotti[3], Silvio Koller[3], Stefan Vogt[3], Sebastian Haefner[3], Uwe Sterr[3], Christian Lisdat[3], Antoine Rolland[1], fred baynes[1], Michel Zampaolo[5], Pierre Thoumany[6], Marco Pizzocaro[6], Benjamin Rauf[6,7], Filippo Bregolin[6,7], Anna Tampellini[6,7], Piero Barbieri[6,7], Massimo Zucco[6], Giovanni Costanzo[6,7], Cecilia Clivati[6], Filippo Levi[6], Davide Calonico[6]; [1]*National Physical Lab, UK;* [2]*Leibniz Universitaet Hannover, Germany;* [3]*Physikalisch-Technische Bundesanstalt, Germany;* [4]*GFZ German Research Centre for Geosciences, Germany;* [5]*Laboratoire Souterrain de Modane, France;* [6]*Istituto Nazionale di Ricerca Metrologica, Italy;* [7]*Politecnico di Torino, Italy.* We discuss the relation between atomic clocks and gravity from two perspectives: gravity potential measurements for optical clock comparisons and contributions to international timesalces and, conversely, the measurement of gravity potential differences using optical clocks.

Executive Ballroom 210G

08:00–10:00
SM1G • Ultra-High Capacity Transmission Techniques & SDM
Presider: Ryan Scott; Keysight Laboratories, USA

SM1G.1 • 08:00 Invited
Recent Advances in Mode-Multiplexed Transmission over Multimode Fibers, Roland Ryf[1], Nicolas K. Fontaine[1], Steffen Wittek[1,2], Karthik Choutagunta[1,3], Mikael Mazur[1,4], haoshuo Chen[1], Juan Carlos Alvarado Zacarias[1,2]; [1]*Nokia Bell Labs, USA;* [2]*CREOL, The Univ. of Central Florida, USA;* [3]*E. L. Ginzton Lab, Stanford Univ., USA;* [4]*Photonics Lab, Chalmers Univ. of Technology, Sweden.* We present latest advances in multimode fibers and components for mode-multiplexed transmission. In particular we will review large mode count mode-multiplexer and characterization techniques for multimode components and provide a summary of the latest transmission results.

SM1G.2 • 08:30
Mode-Multiplexed Transmission with Crosstalk Mitigation Using Amplified Spontaneous Emission (ASE), Yetian Huang[1], Haoshuo Chen[2], Hanzi Huang[1], Yingxiong Song[1], Zhengxuan Li[1], Nicolas K. Fontaine[2], Roland Ryf[2], Juan Carlos Alvarado Zacarias[3], Rodrigo Amezcua Correa[3], Min Wang[1]; [1]*Shanghai Univ., China;* [2]*Nokia Bell Labs, USA;* [3]*Univ. of Central Florida, USA.* We employ the short coherence length property of spectrally filtered amplified spontaneous emission (ASE) noise to mitigate modal crosstalk and demonstrate mode- and wavelength-multiplexed transmission over multimode fiber using a single ASE source.

Executive Ballroom 210H

08:00–10:00
SM1H • Plasmonics for Manipulation & Sensing
Presider: Zijie Yan; Clarkson University, USA

SM1H.1 • 08:00 Invited
Optical Manipulation and Heating of Strongly Absorbing and Gate-Keeping Nanoparticles and Their Use in Nanomedicine, Lene Oddershede[1,2]; [1]*The Niels Bohr Inst., Denmark;* [2]*Novo Nordisk Foundation, Denmark.* We optically trap individual strongly absorbing metallic nanoparticles. Through direct experimental measurements and modeling we quantify the associated heating and demonstrate bio-medical usage, e.g., for cancer treatment, of these plasmonic and gate-keeping nanoparticles.

SM1H.2 • 08:30
Manipulating Fano coupling in the opto-thermoelectric trap, Linhan Lin[1], Xiaolei Peng[1], Yuebing Zheng[1]; [1]*Univ. of Texas at Austin, USA.* We experimentally demonstrate the on-demand assembly of all-dielectric Fano metamolecules in the opto-thermo-electric trap with both reconfigurability and tunability.

07:00–18:00 Registration, *Concourse Level*

Meeting Room 211 A/B

CLEO: Applications & Technology

08:00–10:00
AM1I • Photobiomodulation Therapeutics
Presider: Ilko K. Ilev; U.S. Food and Drug Administration, USA

AM1I.1 • 08:00 Invited
Non-linearity in Photobiomodulation Therapy Dosing - A Photoceutical Approach to a Quantum Biological Process?, Praveen Arany[1]; [1]*Univ. at Buffalo, USA.* The startling breadth of Photobiomodulation Therapy for human health has been somewhat curbed by the inconsistencies in rigorous clinical protocols. Dose-ranging studies in labs and humans have noted the non-linear nature of its therapeutic responses that will be highlighted in this presentation.

AM1I.2 • 08:30 Invited
Near Infrared Photoimmunotherapy for Cancer, Hisataka Kobayashi[1]; [1]*National Inst.s of Health, USA.* Near infrared photoimmunotherapy (NIR-PIT) is a newly-developed, molecularly-targeted cancer photo-therapy based on antibody-photosensitizer conjugates. By crashing cancer cells combined with immuno-activation, NIR-PIT activates anti-cancer immunity resulted in curing local and distant metastatic cancers without recurrence.

Meeting Room 211 C/D

CLEO: Science & Innovations

08:00–10:00
SM1J • Beamforming & Coupling to Free Space
Presider: Harish Subbaraman; Boise State Univ., USA

SM1J.1 • 08:00 Invited
Optical Phased Array Lidar, Michael R. Watts[1]; [1]*Analog Photonics, USA.* Integrated optical phased arrays provide an attractive solution to LiDAR sensors by enabling solid-state, small-form-factor systems fabricated on 300mm wafers. We present recent results including high-performance beam steering and long-range LiDAR up to almost 200m.

SM1J.2 • 08:30
On-chip Wavefront Shaping with High Contrast Dielectric Metalens, Zi Wang[1], Tiantian Li[1], Anishkumar Soman[1], Tingyi Gu[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Delaware, USA.* Compact and lossless on-chip high-contract transmit-array is experimentally demonstrated on a standard SOI substrate. The integrated metalens has a focal spot size of 0.38 λ, transmission of 94% and focusing efficiency of 71%.

Meeting Room 212 A/B

CLEO: Applications & Technology

08:00–10:00
AM1K • Environmental & Atmospheric Sensing I
Presider: Mark Zondlo; Princeton University, USA

AM1K.1 • 08:00 Invited
Cavity Attenuated Phase Shift (CAPS)-Based Detection of Gas Phase Species and Aerosols, Andrew Freedman[1], Timothy Onasch[1], Paul Kebabian[1], Paola Massoli[1,2]; [1]*Aerodyne Research, Inc., USA;* [2]*MultiSensor Scientific Inc, USA.* We describe the use of state-of-the-art monitors that measure both the concentration of nitrogen dioxide and the optical properties of aerosols using Cavity Attenuated Phase Shift (**CAPS**) techniques. Examples of how they are used in the real world include: measuring soot emissions from jet aircraft engines; determining the atmospheric mixing ratio of NO_2 as a function of altitude; and determining the single scattering albedo of ambient aerosols at both ground level and at altitude.

AM1K.2 • 08:30
Methane Leak Detection Using Chirped Laser Dispersion Spectroscopy, Yifeng Chen[1], Michael Soskind[1], James McSpiritt[2], Rui Wang[2], Nathan Li[2], Mark A. Zondlo[2], Gerard Wysocki[1]; [1]*Electrical Engineering, Princeton Univ., USA;* [2]*Civil and Environmental Engineering, Princeton Univ., USA.* We present a real-time chirped laser dispersion spectrometer capable of distinguishing path-averaged methane leaks 0 to 8 ppm above the ~2ppm background methane level using low reflectivity (down to 0.01%) surfaces 50 m away.

Meeting Room 212 C/D

CLEO: Science & Innovations

08:00–10:00
SM1L • Narrow Linewidth Fiber Lasers
Presider: Sze Y. Set The University of Tokyo, Japan

SM1L.1 • 08:00
High-Order Mode Brillouin Fiber Lasers Based on Intra- and Inter-Modal SBS, Ning Wang[1], Juan Carlos Alvarado Zacarias[1], Md. Selim Habib[1], He Wen[1], Yuanhang Zhang[1], Jose Enrique Antonio-Lopez[1], Pierre sillard[2], Adrian Amezcua-Correa[2], Rodrigo Amezcua Correa[1], Guifang Li[1]; [1]*Univ. of Central Florida, CREOL, USA;* [2]*Prysmian Group, France.* We experimentally demonstrated LP_{11} mode Brillouin fiber lasers based on both intra- and inter-modal SBS. The OSNRs were over 65 dB, and their mode profiles were clearly observed for both cases.

SM1L.2 • 08:15
Engineering the lasing properties and dynamics of Brillouin Fiber Lasers using pump modulation, Omer Kotlicki[1], Jacob Scheuer[1]; [1]*Tel-Aviv Univ., Israel.* We demonstrate experimentally a self-stable, bi-frequency and switchable, Brillouin fiber laser at telecom wavelengths with engineered spectral properties. The spectral control is obtained by pump modulation while dynamic switching is achieved through the pump level.

SM1L.3 • 08:30
Single-Frequency, Ultra-Narrow Linewidth Hybrid Brillouin-Thulium Fiber Laser based on In-band Pumping, Chaodu Shi[1], Shijie Fu[1], Quan Sheng[1], wei shi[1], Jianquan Yao[1]; [1]*Tianjin Univ., China.* A hybrid Brillouin/thulium fiber laser with an ultra-narrow linewidth of 0.93 kHz was demonstrated, with the output coupling, cavity Q factor and pumping scheme optimized for the narrow linewidth.

07:00–18:00 Registration, *Concourse Level*

Marriott Salon I & II

CLEO: QELS-Fundamental Science

08:00–10:00
FM1M • Single-Photon Sources
Presider: Mirko Lobino Griffith University, Australia

FM1M.1 • 08:00
Interfacing solid-state single-photon sources and integrated photonics circuits: high rate three-photon coalescence, Carlos Antón Solanas[1,2], Guillaume Coppola[1,2], Juan Carlos Loredo[1,2], Niko Viggianello[3], Helene Ollivier[1,2], Abdelmounaim Harouri[1,2], Niccolo Somaschi[4], Andrea Crespi[5,6], Isabelle Sagnes[1,2], Aristide Lemaitre[1,2], Loic Lanco[1,7], Roberto Osellame[5,6], Fabio Sciarrino[3], Pascale Senellart[1,2]; [1]*CNRS Center of Nanosciences and Nanotechnology, France;* [2]*Universite Paris-Sud, Universite Paris-Saclay, France;* [3]*Dipartimento di Fisica, Sapienza Università di Roma, Italy;* [4]*Quandela, SAS, France;* [5]*Consiglio Nazionale delle Ricerche Istituto di Fotonica e Nanotecnologie, Italy;* [6]*Dipartimento di Fisica, Politecnico di Milano, Italy;* [7]*Université Paris Diderot, France.* We report the interfacing of an integrated solid-state single-photon source with an integrated, reconfigurable photonic tritter demonstrating a highly efficient quantum interference of three indistinguishable single photons.

FM1M.2 • 08:15
Quantum-dot single-photon source on a CMOS-processed silicon waveguide, Ryota Katsumi[1], Yasutomo Ota[2], Alto Osada[2], Takuto Yamaguchi[1], Takeyoshi Tajiri[1], Masahiro Kakuda[2], Satoshi Iwamoto[1,2], Yasuhiko Arakawa[2]; [1]*Inst. of Industrial Science, Japan;* [2]*Inst. for Nano Quantum Information Electronics, Japan.* We report a quantum-dot single-photon source integrated onto a CMOS-processed silicon waveguide. The necessary hybrid integration was done in a simple pick-and-place manner with transfer printing, thus fully maintaining the compatibility with CMOS-back-end technology.

FM1M.3 • 08:30
Integration of Quantum Emitters with Lithium Niobate Photonics, Shahriar Aghaeimeibodi[1], Boris Desiatov[2], Je-Hyung Kim[3], Chang-Min Lee[1], Mustafa Buyukkaya[1], Aziz Karasahin[1], Christopher Richardson[1], Richard Leavitt[1], Marko Loncar[2], Edo Waks[1]; [1]*Univ. of Maryland, USA;* [2]*Harvard Univ., USA;* [3]*Ulsan National Inst. of Science and Technology, South Korea (the Republic of).* We demonstrate integration of telecom quantum dots with lithium niobate photonics using a pick-and-place technique. Second order photon correlation measurement performed with an on-chip beamsplitter confirms the single-photon nature of the emission.

Marriott Salon III

CLEO: Science & Innovations

08:00–10:00
SM1N • Open-path Sensing & Free-electron Lasers
Presider: Erik Emmons; Edgewood Chemical Biological Center, USA

SM1N.1 • 08:00
All-Time Single-Photon 3D Imaging Over 21 km, Zheng-Ping Li[1,2], Xin Huang[1,2], Yuan Cao[1,2]; [1]*Shanghai Branch, Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Synergetic Innovation Center of Quantum Information & Quantum Physics, Univ. of Science and Technology of China, China.* We experimentally demonstrate active three-dimensional (3D) imaging at a range of up to 21.6 km in daylight by constructing a high-efficiency single-photon LiDAR system and developing a long-range-tailored computational algorithm.

SM1N.2 • 08:15
Sequence-Coded Coherent Laser Range Finder, Keren Shemer[1], Gil Bashan[1], Hilel H. Diamandi[1], Yosef London[1], Arik Bergman[1], Nadav Levanon[2], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel;* [2]*Faculty of Engineering, Tal-Aviv Univ., Israel.* A range finder based on an extended sequence of coded pulses is demonstrated. Coherent detection is used to measure the range of weak point reflections, with average energy of only 0.15 photons per code symbol.

SM1N.3 • 08:30
Standoff 250m Open-path Detection of Chemical Plumes Using a Broadband Swept-ECQCL, Mark C. Phillips[1], Bruce E. Bernacki[1], Sivanandan S. Harilal[1], Jeremy Yeak[2], R. J. Jones[3]; [1]*Pacific Northwest National Lab, USA;* [2]*Opticslah, LLC, USA;* [3]*College of Optical Sciences, Univ. of Arizona, USA.* We measure chemical plumes at a 250 m standoff distance by sweeping an external cavity quantum cascade laser over a broad spectral range of 920-1220 cm^{-1} at a rate of 200 Hz.

Marriott Salon IV

08:00–10:00
SM1O • Van der Waals Heterostructures
Presider: Eiichi Kuramochi; NTT, Japan

SM1O.1 • 08:00 Tutorial
Plasmonics in Two-dimensional Crystals, Javier García de Abajo[1,2]; [1]*ICFO-The Inst. of Photonic Sciences, Spain;* [2]*ICREA, Spain.* We will discuss recent advances in the study of fundamental aspects and applications of plasmons in atomic layers of graphene, noble metals, and their combinations in 2D crystal stacks.

Javier García de Abajo is an ICREA Research Professor at ICFO (Barcelona), where he leads the Nanophotonics Theory group. He is Fellow of APS and OSA and has co-authored 370+ articles with 25,000+ citations (WoK h index 78) in the different aspects of surface science, nanophotonics, and electron microscope spectroscopies.

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FM1A • Quantum Optomechanics & Transduction—Continued

FM1A.4 • 09:00
Toward Coherent Control of Single Yb^{3+} Ions in a Nanophotonic Cavity, Jonathan Kindem[1], Andrei Ruskuc[1], John G. Bartholomew[1], Jake Rochman[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA.* We report on detection and coherent optical driving of single Yb^{3+} ions coupled to a nanophotonic resonator fabricated in the YVO_4 host crystal and outline a path toward control of single $^{171}Yb^{3+}$ spins.

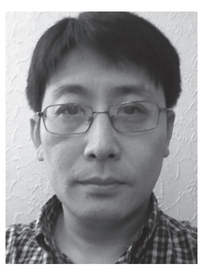
FM1A.5 • 09:15
Toward Quantum Microwave to Optical Conversion using Rare Earth Ion Containing Crystals, Xavier Fernandez-Gonzalvo[1], Gavin G. King[1], Sebastian Horvath[1], Jonathan Everts[1], Matthew Berrington[2], Rose Ahlefeldt[2], Yu-Hui Chen[1], Jevon J. Longdell[1]; [1]*Dodd Walls Center, Univ. of Otago, New Zealand;* [2]*Australian National Univ., Australia.* With an Er:Y$_2$SiO$_5$ crystal at 4K we achieve microwave to optical conversion with quantum efficiency 10^{-5}. Theory and initial results at milli-kelvin temperatures and with fully concentrated rare earth crystals point to significant improvements.

FM1A.6 • 09:30
Coherent Control of Rare-Earth Ions in On-Chip Devices for Microwave-to-Optical Transduction, John G. Bartholomew[1,2], Jake Rochman[1,2], Jonathan Kindem[1,2], Andrei Ruskuc[1,2], Ioana Craiciu[1,2], Mi Lei[1,2], Tian Zhong[1,2], Andrei Faraon[1,2]; [1]*Kavli Nanoscience Inst. and Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA;* [2]*Inst. for Quantum Information and Matter, California Inst. of Technology, USA.* Entangling microwave and optical photons is essential to harness disparate technologies for building larger scale quantum networks. We demonstrate coherent microwave-to-optical transduction using a nanobeam waveguide containing rare-earth ions in a dilution refrigerator.

FM1B • Topological Photonics I—Continued

FM1B.4 • 08:45
Nonlinear Imaging of Topological Edge States in Dielectric Metasurfaces, Daria Smirnova[1], Sergey S. Kruk[1], Daniel Leykam[2], Elizaveta V. Melik-Gaykazyan[1,3], Duk-yong Choi[1], Yuri S. Kivshar[1]; [1]*Australian National Univ., Australia;* [2]*Inst. for Basic Science, South Korea (the Republic of);* [3]*Lomonosov Moscow State Univ., Russia.* We fabricate and characterize nonlinear metasurfaces supporting topological edge states at the nanoscale. By employing spectral-selective excitation, we visualize both bulk photonic modes and propagating topological edge states via third-harmonic imaging.

FM1B.5 • 09:00 Tutorial
Three-dimensional Topological Metamaterials. Biao Yang[1], Hongwei Jia[1], Qinghua Guo[1], Rui-Xing Zhang[2], Wenlong Gao[1], Ben Tremain[3], Rongjuan Liu[4], Lauren E Barr[3], Qinghui Yan[4], Hongchao Liu[1], Jing Chen[5], Jing Hu[1], Yangang Bi[1], Chen Fang[4], Yuanjiang Xiang[6], Alastair Hibbins[3], Ling Lu[4], Chaoxing Liu[7], Shuang Zhang[1]; [1]*Univ. of Birmingham,* [2]*University of Maryland,* [3]*University of Exeter,* [4]*Chinese Academy of Sciences,* [5]*Nankai University,* [6]*Shenzhen University,* [7]*Pennsylvania State University.* I will discuss the realization of 3D topological metamaterials with ideal Weyl points. The photonic 'Fermi arcs' showed Riemann-surface-like helicoid configuration. Artificial magnetic field can be introduced, leading to observation of chiral zero Landau mode.



Professor Shuang Zhang is a professor in the School of Physics & Astronomy, University of Birmingham. He is the recipient of IUPAP Young Scientist Prize in Optics, the Royal Society Wolfson Research Merit Award in 2016. He was elected a Fellow of The Optical Society (OSA) in 2016.

FM1C • Novel Phenomena in Classical Nano-Optics—Continued

FM1C.4 • 08:45
Experimental Observation of Generalized Snell's Law in an Interface Between Different Photonic Artificial Gauge Fields, Moshe-Ishay Cohen[1,2], Christina I. Jörg[3], Yaakov Lumer[1,2], yonatan plotnik[1,2], Georg von Freymann[3,4], Mordechai Segev[1,2]; [1]*Physics Dept., Technion - Israel Inst. of Technology, Israel;* [2]*Solid State Inst., Technion - Israel Inst. of Technology, Israel;* [3]*Physics Dept. and Research Center OPTIMAS, TU Kaiserslautern, Germany;* [4]*Fraunhofer Inst. for Industrial Mathematics ITWM, Germany.* We formulate and experimentally demonstrate generalized laws of refraction and reflection from an interface between two domains with different artificial gauge field.

FM1C.5 • 09:00 Invited
Mesoscopic Correlations and Information in Speckles Emerging from Opaque Scattering Media, Remi Carminati[1], Nikos Fayard[2], Romain Pierrat[1,3], Arthur Goetschy[1], Jacopo Bertolotti[4], Alba Paniagua-Diaz[4], Ilya Starshinov[4]; [1]*ESPCI Paris, France;* [2]*ICFO, Spain;* [3]*CNRS, France;* [4]*Univ. of Exeter, UK.* We demonstrate the existence of mutual information between the speckle patterns generated on both sides of an opaque scattering medium. This opens up new possibilities for the control of light propagation through complex media.

FM1C.6 • 09:30
Experimental study of non-orthogonal modes in tight-binding lattices, Lukas Maczewsky[1], Steffen Weimann[1], Mark Kremer[1], Matthias Heinrich[1], Alexander Szameit[1]; [1]*Inst. of Physics, Univ. of Rostock, Germany.* The non-orthogonality of modes is often neglected yet indispensable for an exactdescription of the dynamics in tight-binding lattices. We devise a compact arrangement to quantify these additional coupling parameters and observe their influence.

FM1D • Coherent Phenomena in Coupled Resonator Networks—Continued

FM1D.3 • 08:45
Self-locked Adiabatic Lasers Solve a Global Optimization Problem, Marco Piccardo[1], Paul Chevalier[1], Benedikt Schwarz[2], Dmitry Kazakov[1], Yongrui Wang[3], Alexey Belyanin[3], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*TU Wien, Austria;* [3]*Texas A&M, USA.* Laser self-locking is a complex, nonlinear phenomenon. We find that in adiabatic frequency combs this can be simply described as a power optimization problem, which the laser can solve for a large number of modes.

FM1D.4 • 09:00
Sub-Harmonic Synchronization of Kerr Frequency Combs, Jae K. Jang[1], Xingchen Ji[1,2], Chaitanya Joshi[1,2], Yoshitomo Okawachi[1], Michal Lipson[1], Alexander L. Gaeta[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA.* We experimentally demonstrate sub-harmonic synchronization of separated soliton-modelocked Kerr frequency combs. Through passive optical coupling between microresonators, we demonstrate entrainments between combs with mode spacings related by integer factors of 2 and 3.

FM1D.5 • 09:30
Nonlinear Interactions in Linearly Uncoupled Resonators, Matteo Menotti[2], Blair Morrison[2], Kang Tan[2], Zachary Vernon[2], John E. Sipe[3], Marco Liscidini[1]; [1]*Università degli Studi di Pavia, Italy;* [2]*Xanadu Quantum Technologies, Canada;* [3]*Univ. of Toronto, Canada.* We demonstrate a system composed of two resonators that are coupled solely through a third-order nonlinear interaction. We show that such a structure has significant advantages in controlling classical and quantum nonlinear interactions in integrated photonics.

Executive Ballroom 210E | Executive Ballroom 210F | Executive Ballroom 210G | Executive Ballroom 210H

Joint | CLEO: Science & Innovations

JM1E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications I—Continued

JM1E.3 • 09:00
High Average Power 106 W, 1.75 μm, 100 kHz Optical Parametric Chirped Pulse Amplifier, Matthew Windeler[1,2], Katalin Mecseki[1], Joseph Robinson[1], James M. Fraser[2], Alan Fry[1], Franz Tavella[1]; [1]*SLAC National Accelerator Lab, USA;* [2]*Dept. of Physics, Astronomy and Engineering Physics, Queen's Univ., Canada.* We explore average power scaling of OPCPA in KTA at signal center wavelengths spanning 1.5 – 2.0 μm. At maximum, the OPCPA produced 106 W, centered at 1.75 μm with a repetition rate of 100 kHz.

JM1E.4 • 09:15 Invited
Nonlinear pulse compression at high average power based on multi-pass cells, Johannes Weitenberg[2,1], Jan Schulte[2], Thomas Sartorius[2], Akira Ozawa[1], Thomas Udem[1], Hans-Dieter Hoffmann[2], Peter Russbueldt[2], Theodor W. Hänsch[1], Reinhart Poprawe[2]; [1]*Laser Spectroscopy, Max-Planck Inst. of Quantum Optics MPQ, Germany;* [2]*Lasers and Laser Optics, Fraunhofer Inst. for Laser Technology ILT, Germany.* We report on the development and recent advances of a nonlinear pulse compression scheme based on multi-pass cells, which is applicable to a large range of pulse energies, highly efficient and power scalable.

SM1F • Optical Clocks—Continued

SM1F.4 • 09:00 Invited
Ultra-stable Optical Atomic Clocks for Geodesy, Tanja Mehlstaeubler[1]; [1]*Physikalisch-Tech Bundesantalt (PTB), Germany.* The dependence of atomic frequencies on the gravitational potential makes atomic clocks interesting candidates for new gravity field sensors, delivering long-term height references for geodetic measurements and for the modelling and understanding of our Earth.

SM1F.5 • 09:30
Optical clocks via breather stabilization in chip-scale frequency combs, Abhinav Vinod[1], Shu-Wei Huang[2], Jinghui Yang[1], Mingbin Yu[3], Dim Lee Kwong[3], Chee Wei Wong[1]; [1]*Univ. of California Los Angeles, USA;* [2]*ECE, Univ. Of Colorado, Boulder, USA;* [3]*Inst. of Microelectronics, Singapore.* Here we report a novel method to generate low noise microwaves via a chip-scale frequency comb and demonstrate noise suppression of the carrier frequency below the microwave stabilization limit achieved.

SM1G • Ultra-High Capacity Transmission Techniques & SDM—Continued

SM1G.3 • 08:45
112 Gb/s CAP-based Data Transmission over 100 m MMF Links using an Artificial Neural Network Equalizer, Xiaohe Dong[1], Nikos Bamiedakis[1], David G. Cunningham[1], Richard V. Penty[1], Ian H. White[1]; [1]*Univ. of Cambridge, UK.* A novel artificial neural network equalizer for use in short-reach optical links is proposed. 112Gb/s and 56Gb/s CAP-16 data transmission are demonstrated by simulation and experiment respectively with receiver sensitivities of -4 and -7 dBm.

SM1G.4 • 09:00 Invited
Meeting Capacity Demand in Undersea Fiber Optic Communication Systems., Alexei N. Pilipetskii[1]; [1]*SubCom, USA.* The capacity demand for future undersea cable networks will push the industry to the cable transmission capacity in excess of hundreds of Tb/s. The new technologies and approaches to address capacity demand will be reviewed.

SM1H • Plasmonics for Manipulation & Sensing—Continued

SM1H.3 • 08:45
Surface-enhanced Raman Spectroscopy of Graphene Integrated in Three-dimensional Nanostructured Plasmonic Silicon Platforms, Maria Kandyla[1], Maria Kanidi[1], Alva Dagkli[2], Nikolaos Kelaidis[3], Dimitris Palles[1], Sigiava Aminalragia-Giamini[3], Jose Marquez-Velasco[3], Allan Colli[4], Athanasios Dimoulas[3], Elefterios Lidorikis[2], Efstratios Kamitsos[1]; [1]*National Hellenic Research Foundation, Greece;* [2]*Univ. of Ioannina, Greece;* [3]*NCSR 'Demokritos', Greece;* [4]*Univ. of Cambridge, UK.* We integrate graphene with 3D plasmonic laser-nanostructured silicon substrates for SERS and we observe broadband 10^3 Raman enhancement. FDTD numerical simulations elucidate the advantages of the substrate topography and the flexibility of 2D materials.

SM1H.4 • 09:00
Polarization-Dependent Optical Binding of Plasmonic Nanoparticles, Fei Han[1], Fan Nan[1], Zijie Yan[1]; [1]*Clarkson Univ., USA.* Plasmonic metal nanoparticles can self-assemble into anisotropic chains in a linearly polarized optical field and ordered hexagonal arrays in a circularly polarized optical field. Negative optical torque can be observed in the arrays.

SM1H.5 • 09:30
Lithography-free hybrid Ag–Au super absorbing metasurfaces for addictive drug sensing, Nan Zhang[1], Dengxin Ji[1], Haomin Song[1], Youhai Liu[1], Lyu Zhou[1], Lorraine Collins[1], Qiaoqiang Gan[1]; [1]*State Univ. of New York at Buffalo, USA.* We demonstrate a lithography-free super absorbing metasurface consisting of hybrid Ag-Au nanoantennas with sub-20-nm nanogaps for surface enhanced Raman spectroscopy sensing to tackle the emerging drug-abuse challenge.

Meeting Room 211 A/B

CLEO: Applications & Technology

AM1I • Photobiomodulation Therapeutics—Continued

AM1I.3 • 09:00
Label-Free Quantitative Classification of Cancer Cells Measured by Interferometric Phase Microscopy, Natan T. Shaked[1]; [1]*Tel-Aviv Univ., Israel*. I will present our latest advances in label-free quantitative imaging flow cytometry for cancer cell classification using external and portable interferometric modules, where the metastatic potential of the cells is detected.

AM1I.4 • 09:15
Cell deformation and assessment with tunable "tug-of-war" optical tweezers, Yi Liang[1,2], Yinxiao Xiang[1,3], Josh Lasmstein[1], Anna Bezryadina[1,4], Zhigang Chen[1,3]; [1]*Dept. of Physics and Astronomy, San Francisco State Univ., USA;* [2]*Guangxi Key Lab for Relativistic Astrophysics, Guangxi Colleges and Universities Key Lab of Novel Energy Materials and Related Technology,School of Physical Science and Technology, Guangxi Univ., China;* [3]*MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [4]*Dept. of Physics and Astronomy, Dept. of Physics and Astronomy, USA.* We assess red-blood-cell (RBC) deformability under different osmotic conditions by employing novel "tug-of-war" optical tweezers. Such a photonic tool enables stable trapping and stretching of single RBCs, attaining over 15% of cell deformation.

AM1I.5 • 09:30
Simultaneous Two- and Three-photon Imaging of Multilayer Neural Activities with Remote Focusing, Aaron Mok[1], Tianyu Wang[1], Fei Xia[1], Chunyan Wu[1], Chris Xu[1]; [1]*Applied Engineering and Physics, Cornell Univ., USA.* We present a novel remote focusing and demultiplexing scheme that allows simultaneous two- and three-photon imaging of two-layer neural activities, featuring large axial separation, independent foci tunability and large imaging depth enabled by three-photon microscopy.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM1J • Beamforming & Coupling to Free Space—Continued

SM1J.3 • 08:45
Achromatic Subwavelength Grating Lens at Visible Bandwidths, Mao Ye[1], Ray Vishva[1], Ya Sha Yi[1]; [1]*Univ. of Michigan, USA.* The polarization intensitive achromatic micro lens covering the whole visible wavelength is demonstrated that can cover 250 nm of visible bandwidths (from 435 nm to 685 nm) with focal shift less than 5%.

SM1J.4 • 09:00
Optical spatial differentiator based on subwavelength high-contrast gratings, Weiji Yang[1], Zhewei Dong[1], Jiangnan Si[1], Xuanyi Yu[1], Xiaoxu Deng[1]; [1]*Shanghai Jiaotong Univ., China.* Based on subwavelength high-contrast gratings (HCGs), a transmissive optical spatial differentiator without Fourier lens is proposed experimentally, which achieves edge detections of images and provides applications in optical computing systems and parallel data processing.

SM1J.5 • 09:15
Using an Integrated Silicon Emitter to Generate Two Coaxial Orbital-Angular-Momentum Beams with Tunable Mode Orders and Broad Bandwidth, Hao Song[1], Zhe Zhao[1], Runzhou Zhang[1], Jing Du[1], Haoqian Song[1], Long Li[1], Kai Pang[1], Cong Liu[1], Ahmed Almaiman[1], Robert Bock[2], Moshe Tur[3], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*R-DEX System, Inc., USA;* [3]*Tel Aviv Univ., Israel.* We design and simulate a broadband integrated silicon emitter to generate two coaxial orbital-angular-momentum beams with tunable mode orders (l = {-1,0} or {0,+1}). Crosstalk <-15 dB is achieved over 1500-1600 nm.

SM1J.6 • 09:30
Achieving Off-Axis Holographic Projections with Uniform Illumination by 3D Printing Blazed Facets on Phase Elements, Hao Wang[1], Yejing Liu[1], Qifeng Ruan[1], Hailong Liu[1], Ray J.H. Ng[1,2], You Sin Tan[1], Joel K. W. Yang[1,2]; [1]*EPD, Singapore Univ. of Technology and Design, Singapore;* [2]*Inst. of Materials Research and Engineering, A*STAR (Agency for Science, Technology and Research), Singapore.* A new design of diffractive optical elements with blazed facets is fabricated using 3D printing to obtain off-axis holograms with uniform illumination. Experimental holograms without zero order spot are achieved, fit well with diffraction theory.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM1K • Environmental & Atmospheric Sensing I—Continued

AM1K.3 • 08:45
Mid-IR Laser Spectrometer for Balloon-borne Lower Stratospheric Water Vapor Measurements, Manuel Graf[1,2], Philipp Scheidegger[1], Herbert Looser[1], Badrudin Stanicki[1], Thomas Peter[2], Lukas Emmenegger[1], Béla Tuzson[1]; [1]*Empa, Switzerland;* [2]*IAC, ETH, Switzerland.* A lightweight instrument has been developed to measure water vapor up to the lower stratosphere aboard meteorological balloons. The sensor relies on a segmented circular multipass cell which is especially suited for mobile field applications.

AM1K.4 • 09:00
Imaging Technique for In Situ Cloud Characterization, Andrei B. Vakhtin[1], Lev N. Krasnoperov[2]; [1]*Mesa Photonics, LLC, USA;* [2]*New Jersey Inst. of Technology, USA.* An imaging technique for in situ characterization of droplets in atmospheric clouds based on analysis of scattered light from droplets illuminated by a pulsed spectrally broadband light source is presented.

AM1K.5 • 09:15 Invited
Development of a Compact CO_2 Instrument for Small Aerial Platform, Anthony Gomez[1], Joel A. Silver[1]; [1]*Southwest Sciences Inc, USA.* High accuracy CO_2 instrumentation for airborne platforms would bridge the gap between land and satellite measurements. Here we present ongoing work on a novel temperature and pressure compensated sensor for measuring dry-air corrected CO_2 concentrations.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM1L • Narrow Linewidth Fiber Lasers—Continued

SM1L.4 • 08:45
Direct Frequency Locking of a Diode Laser to a Meter-Long High-Finesse Fiber Fabry-Perot Cavity, Nabil Md Rakinul Hoque[1], Lingze Duan[1]; [1]*Univ. of Alabama in Huntsville, USA.* We report the demonstration of directly locking the frequency of a diode laser to a meter-long, high-finesse (~1000) fiber Fabry-Perot cavity. This work can serve as a key step toward ultra-sensitive infrasonic strain sensors.

SM1L.5 • 09:00
Rapid and Continuously Tunable Narrow Linewidth Fiber Source Based on a SOA and a Linearly Chirped Fiber Bragg Grating, Xiong Yang[1,2], Robert Lindberg[1], Walter Margulis[1,3], Krister Fröjdh[4], Fredrik Laurell[1]; [1]*Applied Physics, Royal Inst. of Technology (KTH), Sweden;* [2]*College of Optical Science and Engineering, Zhejiang Univ., China;* [3]*Fiber Optics, RISE Acreo, Sweden;* [4]*Proximion AB, Sweden*. We demonstrate a tunable narrow-linewidth laser based on a semiconductor optical amplifier and a linearly chirped FBG. High tuning resolution and small power variation over 40 nm tuning range were achieved by optimizing the drive current.

SM1L.6 • 09:15
Longitudinal Modes in Random Feedback Fiber Lasers, Pedro Tovar[1], Luis Y. Herrera[1], Guilherme P. Temporão[1], Jean Pierre von der Weid[1]; [1]*PUC-Rio, Brazil.* An SOA-based random fiber laser is experimentally demonstrated with multimode operation dominant for high SOA currents. Single mode prevails only near the threshold current. Mode lifetime of ~1 ms and 6 kHz linewidth were measured.

Marriott Salon I & II

CLEO: QELS-Fundamental Science

FM1M • Single-Photon Sources—Continued

FM1M.4 • 08:45
Coherent Coupling of Single Molecules to a Chip-Based Optical Circuit, Dominik Rattenbacher[1], Alexey Shkarin[1], Jan Renger[1], Tobias Utikal[1], Stephan Götzinger[2,1], Vahid Sandoghdar[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Friedrich-Alexander Univ. Erlangen-Nürnberg, Germany.* We present the coherent coupling of single dye molecules to subwavelength waveguides (nanoguides) and microresonators made of TiO_2 on a chip. Integrated electrodes allow us to tune several molecules into resonance via the Stark effect.

FM1M.5 • 09:00
Controlled Assembly of an Ultrafast Single-Photon Source, Oksana Makarova[1], Simeon Bogdanov[1], xiaohui xu[1], Deesha Shah[1], Alexander Baburin[2], Ilya Ryzhikov[2], Soham Saha[1], Ilya Rodionov[2], Alexander Kildishev[1], Alexandra Boltasseva[1], Vladimir M. Shalaev[1]; [1]*Purdue Univ., USA;* [2]*FMNS REC, Bauman Moscow State Technical Univ., Russia.* We demonstrate a technique for highly controllable assembly of single-photon sources coupled to plasmonic nanoantennas with optimal emitter positioning on the nanoscale, resulting in fluorescence decay rates beyond 10 GHz in single nitrogen-vacancy centers.

FM1M.6 • 09:15
Spin Coherence in Single NV Centers Coupled to Controllably Assembled Nanopatch Antennas, Simeon Bogdanov[1], Oksana Makarova[1], Alexei Lagutchev[1], Deesha Shah[1], Chin-Cheng Chiang[1], Alexander Baburin[2,3], Ilya Ryzhikov[2,4], Soham Saha[1], Ilya Rodionov[2,3], Alexandra Boltasseva[1], Vladimir M. Shalaev[1]; [1]*Purdue Univ., USA;* [2]*FMNS REC, Bauman Moscow State Technical Univ., Russia;* [3]*Dukhov Research Inst. of Automatics, Russia;* [4]*Inst. for Theoretical and Applied Electromagnetics, Russian Academy of Sciences, Russia*. We transfer a pre-characterized nanodiamond with a single nitrogen-vacancy (NV) center onto an epitaxial silver substrate and deterministically couple it to a nanopatch antenna. The NV retains its coherent spin dynamics in this process.

FM1M.7 • 09:30
Tailoring nanophotonic frequency converters for quantum dots single-photon sources, Anshuman Singh[1,2], Qing Li[3], Shunfa Liu[4], Ying Yu[4], Christian Schneider[5], Sven Höfling[5,6], John Lawall[1], Varun B. Verma[7], Richard P. Mirin[7], Sae Woo Nam[7], Jin Liu[4], Kartik Srinivasan[1]; [1]*Physical Measurement Lab, National Inst. of Standards and Technology, USA;* [2]*Maryland NanoCenter, Univ. of Maryland, College Park, USA;* [3]*Electrical and Computer Engineering, Carnegie Mellon Univ., USA;* [4]*School of Electronics and Information Technology, Sun-Yat Sen Univ., China;* [5]*Technische Physik, Univ. of Würzburg, Germany;* [6]*School of Physics and Astronomy, Univ. of St Andrews, UK;* [7]*Phyiscal Measurement Lab, National Inst. of Standards and Technology, USA.* We demonstrate the suitability of silicon nanophotonic frequency converters for use with quantum dot single-photon sources. Preservation of photon statistics, operation across an 840-980 nm input wavelength band, and tunable wavelength shifts are shown.

Marriott Salon III

CLEO: Science & Innovations

SM1N • Open-path Sensing & Free-electron Lasers—Continued

SM1N.4 • 08:45
Nyquist-Limited Efficient Fourier-Transform Spectroscopy, Kazuki Hashimoto[1,2], Takuro Ideguchi[1,3]; [1]*Dept. of Physics, The Univ. of Tokyo, Japan;* [2]*Aeronautical Technology Directorate, Japan Aerospace Exploration Agency, Japan;* [3]*PRESTO, Japan Science and Technology Agency, Japan.* We demonstrate Nyquist-limited efficient Fourier-transform spectroscopy running at a high-scan rate of over 12 kHz with a spectral resolution of 11.5 GHz and a spectral bandwidth of over 1.5 THz.

SM1N.5 • 09:00
Experimental Demonstration of Enhanced Accuracy of Beam Radial Displacement and Azimuthal Rotation Measurements using Enhanced Gradient of a Beam Composed of Multiple Orbital-Angular-Momentum Modes, Jing Du[1], Zhe Zhao[1], Guodong Xie[1], Runzhou Zhang[1], Long Li[1], Haoqian Song[1], Kai Pang[1], Cong Liu[1], Hao Song[1], Moshe Tur[2], Shlomo Zach[2], Nadav Cohen[2], Alan E. Willner[1]; [1]*USC, USA;* [2]*Tel Aviv Univ., Israel*. We experimentally demonstrate beam radial displacement and azimuthal rotation angle measurements using the intensity gradient of multiple OAM modes. Compared with a Gaussian beam or a beam carrying two opposite OAM modes, using multiple OAM modes can improve the measurement accuracy.

SM1N.6 • 09:15
A Compact, Low Loss Integrated Continuous-Time Electro Optic-PLL with Maximum Range of >3.3m, Sohail Ahasan[1], Ali Binaie[1], Christopher T. Phare[1], Michal Lipson[1], Harish Krishnaswamy[1]; [1]*Columbia Univ., USA.* We present a Continuous Time ElectroOptic PLL which not only breaks the fundamental trade-off between chirp bandwidth and Mach Zender Interferometer (MZI) delay but also completely eliminates spurs from the PLLand laser output by using IQ single-sideband (SSB) and harmonic reject (HR) mixing.

SM1N.7 • 09:30 Invited
Microscale Magnetic Devices for Ultra-Compact Free Electron Lasers, Robert Candler[1,2]; [1]*Electrical and Computer Engineering, Univ. of California, Los Angeles, USA;* [2]*California NanoSystems Inst., USA.* We will discuss efforts toward extreme miniaturization of free electron layers through batch-fabrication of electromagnets that are used to create miniature electron beam optical components, such as quadrupoles and undulators.

Marriott Salon IV

SM1O • Van der Waals Heterostructures—Continued

SM1O.2 • 09:00
Near ultraviolet light emission in hexagonal boron nitride based van der Waals heterostructures, Sanghoon Chae[1], Dongjea Seo[2], Qingrui Cao[1], Xiang Hua[1], En-Min Shih[1], Takashi Taniguchi[3], Kenji Watanabe[3], Junyoung Kwon[2], Gwan-Hyoung Lee[2], Cory R. Dean[1], David Schiminovich[1], Irving P. Herman[1], Heon-jin Choi[2], Ioannis Kymissis[1], Young Duck Kim[4], James Hone[1]; [1]*Columbia Univ., USA;* [2]*Dept. of Materials Science and Engineering, Yonsei Univ., South Korea (the Republic of);* [3]*National Inst. for Materials Science, Japan;* [4]*Dept. of Physics, Kyung Hee Univ., South Korea (the Republic of).* We demonstrate light emitting devices consisting of graphene layers separated and by thin hexagonal boron nitride (hBN) with additional hBN encapsulation. At high bias through two graphene layer, thin hBN produce near ultraviolet (NUV) light emission at 394 nm.

SM1O.3 • 09:15
A low-power optoelectronic memory device based on MoS_2/BN/graphene heterostructure, Hongzhu Jiang[1], Shuchao Qin[1], Anran Wang[1], Frank (Fengqiu) Wang[1]; [1]*Nanjing Univ., China.* A low-power optoelectronic memory device is demonstrated by charge trapping in a MoS_2/BN/graphene heterostructure. The miniaturized structure, large current switching ratio (~6×10^5) and fast read/write speed (50 ms) suggest its potential in integrated non-volatile storage cell.

SM1O.4 • 09:30
Localized Bright Luminescence of Indirect Excitons and Trions in a Type II Van der Waals Heterostructure, Erica Calman[1], Lewis Fowler-Gerace[1], Leonid Butov[1], Dmitri Nikonov[2], Ian Young[2], Sheng Hu[3], Artem Mishchenko[3], Andrei Geim[3]; [1]*Univ. of California, San Diego, USA;* [2]*Intel Corporation, USA;* [3]*Univ. of Manchester, UK.* We observe order of magnitude intensity enhancement and narrow, 4 meV, linewidth of luminescence of indirect (interlayer) neutral and charged excitons in localized spot in $MoSe_2$/WSe_2 heterostructure. The indirect trion binding energy is 26 meV.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FM1A • Quantum Optomechanics & Transduction—Continued

FM1A.7 • 09:45
Toward Microwave-to-Optical Conversion using Erbium Doped Crystals and Integrated Resonators, Jake Rochman[1], John Bartholomew[1], Ioana Craiciu[1], Chuting Wang[1], Tian Xie[1], Jonathan Kindem[1], Keith Schwab[1], Andrei Faraon[1]; [1]*Caltech, USA*. We present progress towards a bidirectional coherent microwave-to-optical photon converter using an ensemble of rare-earth ions coupled to integrated photonic and microwave resonators.

FM1B • Topological Photonics I—Continued

FM1C • Novel Phenomena in Classical Nano-Optics—Continued

FM1C.7 • 09:45
Absence of frequency ranges of undirectional propagation in nonreciprocal plasmonics, Siddharth Buddhiraju[1], Yu Shi[1], Alex Song[1], Casey Wojcik[1], Momchil Minkov[1], Ian Williamson[1], Avik Dutt[1], Shanhui Fan[1]; [1]*Stanford Univ., USA*. Surface plasmon-polaritons at a metal-dielectric interface are believed to support a unidirectional frequency range under a magnetic field, where a violation of the time-bandwidth constraint is possible. We show that such unidirectionality is nonphysical.

FM1D • Coherent Phenomena in Coupled Resonator Networks—Continued

FM1D.6 • 09:45
Coupled Degenerate Parametric Oscillators Towards Photonic Coherent Ising Machine, Yoshitomo Okawachi[1], Mengjie Yu[1,2], Xingchen Ji[1,2], Jae K. Jang[1], Michal Lipson[1], Alexander Gaeta[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA*. We demonstrate on-chip coupling between degenerate parametric oscillators (OPO's) in two different silicon nitride microresonators. The system offers potential towards creating a network of OPO's for the realization of a photonic coherent Ising machine.

08:30–12:30 SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)
SC352: Introduction to UltrafastPulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)
SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)
SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)
SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)

10:00–10:30 Coffee Break, *Concourse Level*

11:00–12:00 OSA Presentation Feedback Program, *University Room, Hilton San Jose*

11:00–12:00 Navigate Your Leadership Trajectory for Senior Leaders, *Salon VI, San Jose Marriott*

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H
Joint	CLEO: Science & Innovations		

JM1E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications I—Continued

JM1E.5 • 09:45
Compact, high-efficiency, ultrafast 2-cycles sources at 1030nm, Florent Guichard[1], Loïc Lavenu[1], Michele Natile[1], Xavier Delen[2], Yoann Zaouter[1], Marc Hanna[2], Patrick Georges[2]; [1]*Amplitude Laser Group, France;* [2]*Laboratoire Charles Fabry, France.* We present a dual-stage nonlinear compression scheme generating 6.8fs pulses, with a transmission of 61%. The system's compactness, stability, and average power makes it ideally suited to drive high photon flux XUV sources through HHG.

SM1F • Optical Clocks—Continued

SM1F.6 • 09:45
Absolute frequency measurement of molecular iodine hyperfine transition at 534 nm with a femtosecond optical comb, Feihu Cheng[1], Ke Deng[1], Kui Liu[1], Hongli Liu[1], Jie Zhang[1], Zehuang Lu[1]; [1]*School of Physics, Huazhong Univ. of Science and Technology, China.* We report absolute frequency measurements of the a_{21} component of the rovibrational transition of molecular iodine R(53) 31-0 transitions at 534 nm by modulation transfer spectroscopy with an optical frequency comb.

SM1G • Ultra-High Capacity Transmission Techniques & SDM—Continued

SM1H • Plasmonics for Manipulation & Sensing—Continued

SM1H.6 • 09:45
High Color Conversion Efficiency for Monolayer WSe_2 Using Plasmonic Metasurface, Cheng-Yuan Chen[1], Chen-An Lin[1], Hsiang-Ting Lin[2], Chiao-Yun Chang[2], Hao-Chung Kuo[1], Min-Hsiung Shih[1,2]; [1]*National Chiao Tung Univ., Taiwan;* [2]*Academia Sinica, Taiwan.* Color conversion is a potential answer to enhancing the spontaneous emission of transition metal dichalcogenide (TMDC) atomic layer. Therefore, our experiment utilized silver nanodisk to manipulate the color conversion effect between WSe_2 and quantum dots.

08:30–12:30 SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)
SC352: Introduction to UltrafastPulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)
SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)
SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)
SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)

10:00–10:30 Coffee Break, *Concourse Level*

11:00–12:00 OSA Presentation Feedback Program, *University Room, Hilton San Jose*

11:00–12:00 Navigate Your Leadership Trajectory for Senior Leaders, *Salon VI, San Jose Marriott*

Meeting Room
211 A/B

CLEO: Applications & Technology

AM1I • Photobiomodulation Therapeutics—Continued

AM1I.6 • 09:45
Laser versus radiofrequency catheter ablation of myocardium, Karina S. Litvinova[1], Maria Chernysheva[5,2], Igor Kudelin[5], Sergei Khalimanenko[4], Francisco Leyva[1,3]; [1]*Aston Medical Research Inst., Aston Univ., UK;* [2]*Leibniz Inst. of Photonic Technology, Germany;* [3]*Queen Elisabeth Hospital, UK;* [4]*First Moscow State Medical Univ. (Sechenov Univ.), Russia;* [5]*Aston Inst. of Photonic Technologies, Aston Univ., UK.* Cardiac ablation is a procedure for heart rhythm problems correction. Laser can create controlled irreversible myocardial lesions without crater formation. We confirmed laser produced similar lesions as RF, without undesirable effects on the ventricular walls.

Meeting Room
211 C/D

CLEO: Science & Innovations

SM1J • Beamforming & Coupling to Free Space—Continued

SM1J.7 • 09:45
One-chip Integrated Near-field Thermophotovoltaic Devices Using Intermediate Transparent Substrates, Takuya Inoue[1], Takaaki Koyama[2], Dongyeon D. Kang[2], Takashi Asano[2], Susumu Noda[1,2]; [1]*Photonics and Electronics Science and Engineering Center, Kyoto Univ., Japan;* [2]*Dept. of Electronic Science and Engineering, Kyoto Univ., Japan.* We develop one-chip near-field thermophotovoltaic devices, where thin-film thermal emitters (>1000K) and solar cells are integrated to the top and bottom of intermediate substrates with a sub-wavelength gap (<150nm), realizing 10-fold enhancement in the photocurrent.

Meeting Room
212 A/B

CLEO: Applications & Technology

AM1K • Environmental & Atmospheric Sensing I—Continued

AM1K.6 • 09:45
Multi-Species Environmental Gas Sensing Using Drone-Based Fourier-Transform Infrared Spectroscopy, Marius Rutkauskas[1], Martin Asenov[2], Subramanian Ramamoorthy[2], Derryck Reid[1]; [1]*Heriot-Watt Univ., UK;* [2]*Informatics Forum, Univ. of Edinburgh, UK.* We report a broadband FTIR spectrometer integrated with an autonomous UAV enabling quantitative aerial surveys of multiple gas species simultaneously with a demonstrated sensitivity of 37 ppm and an estimated noise-limited performance of 18 ppm.

Meeting Room
212 C/D

CLEO: Science & Innovations

SM1L • Narrow Linewidth Fiber Lasers—Continued

08:30–12:30 SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)
SC352: Introduction to UltrafastPulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)
SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)
SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)
SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)

10:00–10:30 Coffee Break, *Concourse Level*

11:00–12:00 OSA Presentation Feedback Program, *University Room, Hilton San Jose*

11:00–12:00 Navigate Your Leadership Trajectory for Senior Leaders, *Salon VI, San Jose Marriott*

Marriott
Salon I & II

Marriott
Salon III

Marriott
Salon IV

CLEO: QELS-Fundamental Science

FM1M • Single-Photon Sources—Continued

CLEO: Science & Innovations

SM1N • Open-path Sensing & Free-electron Lasers—Continued

SM1O • Van der Waals Heterostructures—Continued

SM1O.5 • 09:45
Deeply-submicron confocal photoluminescence spectroscopy and edge recombination in WS_2-WSe_2 lateral heterostructure monolayer crystals, Jin ho Kang[1], Abhinav Kumar Vinod[1], Jiahui Huang[1], Zhangji Zhao[1], Peng Chen[3], Laurent Bentolila[2], Xiangfeng Duan[4], Chee Wei Wong[1]; [1]*Electrical and Computer Engineering, Univ. of California, Los Angeles, USA;* [2]*California NanoSystems Inst., Univ. of California, Los Angeles, USA;* [3]*Material and Science Engineering, Univ. of California, Los Angeles, USA;* [4]*Chemistry and Biochemistry, Univ. of California, Los Angeles, USA.* We conducted confocal micro-photoluminescence spectroscopy to scan a WS_2-WSe_2 lateral heterostructure sample using oil emerged microscopy method. We observed enhanced PL lines at the edges of WSe_2 and spatially enhanced PL at tip of the v-shaped areas.

08:30–12:30 SC270: High Power Fiber Lasers and Amplifiers (W. Andrew Clarkson, Optoelectronics Research Center, University of Southampton, UK)
SC352: Introduction to UltrafastPulse Shaping - Principles and Applications (Marcos Dantus, Michigan State University, USA)
SC361: Coherent Mid-IR Light: Generation and Applications (Konstantin Vodopyanov, The College of Optics & Photonics, University of Central Florida, USA)
SC477: Laser Radar and Remote Sensing: An Application-oriented Introduction (Fabio Di Teodoro, Raytheon, USA)
SC481: Fundamentals and Applications of VCSELs (Kent Choquette, University of Illinois, USA)

10:00–10:30 Coffee Break, *Concourse Level*

11:00–12:00 OSA Presentation Feedback Program, *University Room, Hilton San Jose*

11:00–12:00 Navigate Your Leadership Trajectory for Senior Leaders, *Salon VI, San Jose Marriott*

Monday, 10:30–12:30

Executive Ballroom 210A

CLEO: QELS-Fundamental Science

10:30–12:30
FM2A • Quantum Optics of Atoms and Molecules
Presider: Rudolph Kohn; Space Dynamics Laboratory, USA

FM2A.1 • 10:30
Entanglement Between a Photonic Time-Bin Qubit and a Collective Atomic Spin Excitation, Pau Farrera[1], Georg Heinze[1], Hugues de Riedmatten[1,2]; [1]*ICFO - The Insitute of Photonic Sciences, Spain;* [2]*ICREA-Institució Catalana de Recerca i Estudis Avançats, Spain.* Light-matter entanglement combines the long-distance transmission advantage of photonic qubits with the storage and processing capabilities of atomic qubits. In this work we used a laser-cooled atomic cloud to generate entanglement between photonic time-bin qubits and atomic spin excitations.

FM2A.2 • 10:45
Configurable Beam Splitting of Single Photon in Cold Atoms, Yefeng Mei[1], Xianxin Guo[1], Shengwang Du[1]; [1]*the Hong Kong Univ of Sci & Tech, Hong Kong.* We demonstrate a dynamically configurable beam splitter (BS) for single photon wavepacket via electromagnetically-induced-transparency storage in cold atoms. This quantum-memory based controllable BS may have applications in a quantum information processing network.

FM2A.3 • 11:00
Spectral Compression of Narrowband Single Photons with a Near Resonant Cavity, Mathias Seidler[2], Xi Jie Yeo[1], Alessandro Cere[2], Christian Kurtsiefer[2,1]; [1]*National Univ. of Singapore, Singapore;* [2]*Centre for Quantum Technologies, NUS, Singapore.* We compress the spectrum of narrowband heralded single photons generated by four-wave mixing in cold ^{87}Rb atoms using a near-resonant cavity as dispersion medium, without reducing the brightness and almost matching the atomic linewidth.

Executive Ballroom 210B

Joint

10:30–12:30
JM2B • Symposium on Nonreciprocal Photonics I

JM2B.1 • 10:30 Invited
Nonreciprocal and topological photonics, Andrea Alu[1]; [1]*CUNY Advanced Science Research Center, USA.* In this talk, we will overview our recent progress in inducing strong nonreciprocal responses in nanophotonic devices and metasurfaces, and the role of their symmetry breaking features in the realization of topological photonic metamaterials.

JM2B.2 • 11:00
Direct Observation of Topological Edge States in Silicon Photonic Crystals, Nikhil Parappurath[1], Filippo Alpeggiani[2], L. Kuipers[2], Ewold Verhagen[1]; [1]*Center for Nanophotonics, AMOLF, Netherlands;* [2]*Dept. of Quantum Nanoscience, Kavli Inst. of Nanoscience, Delft Univ. of Technology, Netherlands.* We directly observe the states of topological photonic crystals at telecom wavelengths. Using the states' intrinsic radiation, we measure dispersion, loss, pseudospin, and spin-spin scattering. We image spin-selective unidirectional propagation around sharp corners and junctions.

Executive Ballroom 210C

CLEO: QELS-Fundamental Science

10:30–12:15
FM2C • Nonlinear Nano-Optics
Presider: Thomas A. Searles Howard; Univ. USA

FM2C.1 • 10:30
Nonlinear Nanoimaging of Ultrafast Coherent Dynamics of Graphene, Tao Jiang[1,2], Vasily Kravtsov[1,2], Mikhail Tokman[3], Alexey Belyanin[4], Markus B. Raschke[1,2]; [1]*Dept. of Physics, Dept. of Chemistry, and JILA, Univ. of Colorado, USA;* [2]*Center for Experiments on Quantum Materials, Univ. of Colorado, USA;* [3]*Inst. of Applied Physics, Russian Academy of Sciences, Russia;* [4]*Dept. of Physics and Astronomy, Texas A&M Univ., USA.* Using femtosecond adiabatic plasmonic nanofocusing, we image graphene in broadband four-wave mixing, revealing spatial heterogeneity, 6 fs coherent dynamics, and a long range spatial nonlocality.

FM2C.2 • 10:45
Efficient four wave mixing and low-loss in-coupling in hybrid gap plasmonic waveguides, Nicholas A. Güsken[1], Michael Nielsen[1], Ngoc Nguyen[1], Xingyuan Shi[1], Paul Dichtl[1], Stefan Maier[1], Rupert Oulton[1]; [1]*Physics, Imperial College London, UK.* We show efficient four-wave-mixing over µm length-scales with a signal-to-idler conversion efficiency of 1% enabled by strong non-linearities and highly confined fields. Furthermore, we demonstrate low-loss in-coupling into nanometer gaps with an efficiency of 80%.

FM2C.3 • 11:00
Tailoring Second Harmonic Diffraction in GaAs Metasurfaces via Crystal Orientation, Polina Vabishchevich[1,2], Aleksandr Vaskin[3], Sadhvikas Addamane[4], Sheng Liu[1,2], Andrei P. Sharma[4], Ganesh Balakrishnan[4], John Reno[1,2], Gordon Keeler[1], Michael B. Sinclair[1], Isabelle Staude[3], Igal Brener[1,2]; [1]*Sandia National Labs, USA;* [2]*Center for Integrated Nanotechnologies, USA;* [3]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany;* [4]*Center for High Technology Materials (CHTM), Univ. of New Mexico, Albuquerque, New Mexico USA, USA.* We use GaAs metasurfaces with (111) crystal orientation to channel the second harmonic generation (SHG) into the zero-diffraction order that is suppressed for SHG obtained from GaAs metasurfaces with (100) orientation.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

10:30–12:30
FM2D • Ultrafast Optical Processes in Topological Materials
Presider: Ulrike Woggon Techniche Universitaet Berlin, Germany

FM2D.1 • 10:30 Tutorial
Optical Properties of Topological Materials, Allan H. MacDonald[1]; [1]*Univ. of Texas at Austin, USA.* Topological materials, including Chern (quantum Hall) insulators and quantum spin Hall and quantum valley Hall insulators in two dimensions and topological semimetals in three dimensions have a number of distinct optical properties. My tutorial will discuss how these can be used to identify new topological materials, and how they might be valuable for applications.

Allan H. MacDonald received his B.Sc. degree from St. Francis Xavier University, Antigonish, Nova Scotia, Canada in 1973, and M.Sc. and Ph.D. degrees in physics from the University of Toronto in 1974 and 1978 respectively. He was a member of the research staff of the National Research Council of Canada from 1978 to 1987 and has taught at Indiana University (1987-2000) and the University of Texas at Austin (2000-present).

Executive Ballroom 210E

10:30–12:30
JM2E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications II

JM2E.1 • 10:30 Invited
High Peak Power, High Average Power Lasers at the CLF and Their Potential Applications, Cristina Hernandez-Gomez[1]; [1]*STFC Rutherford Appleton Lab, UK.* The continued advancement of short pulse lasers with high average power is crucial for to enable a range of applications. We describe the current performance achieved at the CLF for increasing average power of high power lasers.

JM2E.2 • 11:00
Thermally Induced Spatiotemporal Aberrations in High Average Power Ultrashort Compressors, Zeudi Mazzotta[1], Lucas Ranc[1,2], Nathalie Lebas[1], Catherine Le Blanc[1], Ji Ping Zu[1], Luc Martin[1], François Mathieu[1], Frédéric Druon[3], Dimitris Papadopoulos[1]; [1]*Laboratoire pour l'Utilisation des Lasers Intenses, CNRS, Ecole Polytechnique, CEA, France;* [2]*THALES LAS FRANCE SAS, France;* [3]*Laboratoire Charles Fabry, Institut d'Optique, CNRS, Univ. Paris Saclay, France.* We study the heating effects of the gratings of an ultrashort pulse compressor using a kW laser diode as thermal source. Based on wavelength-dependent wavefront measurements we evaluate the spatiotemporal impact on the compressed pulses.

Executive Ballroom 210F

10:30–12:30
SM2F • Quantum Sensing in Solid State Systems
Presider: Eisuke Abe; RIKEN, Japan

SM2F.1 • 10:30 Invited
Quantum Microscopy for Magnetic and Electrical Nanometrology, Christian Degen[1]; [1]*Dept. of Physics, ETH Zurich, Switzerland.* Diamond nanoprobes with single NV centers allow enhancing scanning probe microscopy with quantum metrology. This talk introduces the basic concepts and technology of diamond nanoprobes and provides illustrations of nanoscale imaging of magnetism and currents.

SM2F.2 • 11:00
High-Sensitivity Magnetometry at Room Temperature with Post-Processed Optical Readout of Single NV-Centres, Antonio Gentile[1], Raffaele Santagati[1], Sebastian Knauer[2], Simon Schmitt[3], Stefano Paesani[1], Chris Granade[4], Nathan Wiebe[4], Christian Osterkamp[3], Liam P. McGuinness[3], Jianwei Wang[1], Mark G. Thompson[1], John G. Rarity[1], Fedor Jelezko[3], Anthony Laing[1]; [1]*Univ. of Bristol, UK;* [2]*Univ. of New South Wales, Australia;* [3]*Ulm Univ., Germany;* [4]*Microsoft Research, USA.* Optical readout from nanofabricated single NV centres is enhanced via Bayesian inference techniques, to demonstrate efficient magnetometry at room temperature conditions. We achieve experimentally Heisenberg-limited sensitivities O (100 nT $s^{1/2}$), thus competing with state-of-art cryogenic set-ups.

Executive Ballroom 210G

10:30–12:15
SM2G • Free-Space & Underwater Communication
Presider: Mihaela Dinu; LGS Innovations, USA

SM2G.1 • 10:30
An Outdoor Evaluation of 1-Gbps Optical Wireless Communication using AlGaN-based LED in 280-nm Band, Yuki Yoshida[1], Kazunobu Kojima[2], Masaki Shiraiwa[1], Yoshinari Awaji[1], Atsushi Kanno[1], Naokatsu Yamamoto[1], Shigefusa Chichibu[2], Akira Hirano[3], Masamichi Ippommatsu[3]; [1]*National Inst of Information & Comm Tech, Japan;* [2]*Inst. for Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan;* [3]*UV Craftory Co. Ltd., Japan.* The performance of solar-blind optical wireless communication using AlGaN-based LED at 280 nm-band was evaluated experimentally over a 1.5-m outdoor Line-of-Sight channel. Even under the summer sun, 1.18-Gbps error-free transmission was achieved.

SM2G.2 • 10:45
Modelling of a deep space FSO-link with a SNSPD receiver unit under turbulence-induced fading conditions, Hristo Ivanov[1], Erich Leitgeb[1], Gert Freiberger[1]; [1]*Graz Univ. of Technology, Austria.* Performance of a deep space FSO-link incorporating SNSPD parametrized with deadtime, QE and N-array is addressed. Considering atmospheric turbulence fading ≤3.5 dB, data rate up to 20 Mbps for -17 (ph/ns)[dB] received signal is reached.

SM2G.3 • 11:00 Invited
Progress in Free Space Optical Networks, Linda Thomas[1]; [1]*US Naval Research Lab, USA.* Free space optical communication systems can provide high bandwidth data transport over line-of-sight paths. Losses due to atmospheric scintillation and obscurations present challenges to data transport reliability. Progress in networking of free space optical systems will be discussed.

Executive Ballroom 210H

10:30–12:30
SM2H • Optical Imaging & Sensing
Presider: Haifeng Jiang; NTSC, USA

SM2H.1 • 10:30
Absolute distance measurement with a long ambiguity range using a tri-comb mode-locked fiber laser, Ting Li[1], Xin Zhao[1], Jie Chen[1], Jianjun Yang[1], Qian Li[1], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Beijing Advanced Innovation Center for Big Date-based Precision Medicine, China.* An absolute distance measurement scheme based on a single triple-comb mode-locked fiber laser is demonstrated. It can realize much longer ambiguity range for real-time measurement with a very simple fiber-optic system setup.

SM2H.2 • 10:45
Two-color Dual-comb Ranging Without Precise Environmental Sensing, Zebin Zhu[1], Kai Ni[1], Qian Zhou[1], Guanhao Wu[1]; [1]*Dept. of Precision Instrument, Tsinghua Univ., China.* We present a two-color dual-comb ranging (TC-DCR) system without precise environmental sensing. The experimental result demonstrates 46 nm precision with 0.1 s coherent averaging and achieves an accuracy of the order of ~10^{-7}.

SM2H.3 • 11:00
Fast and Sensitive Quantitative Phase Imaging Using a Frequency Comb, Jeeranan Boonruangkan[1], Hamid Ferrokhi[1,2], Samuel Kwok[1], Tom Carney[1], Young-Jin Kim[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Wellman Center for Photomedicine, Massachusetts General Hospital, and Harvard Medical School, USA.* We report frequency-comb-based quantitative phase imaging (FCR-QPI) providing coherence tunability for better phase sensitivity with suppressed background noise. FCR-QPI can also enable monitoring of fast inter- and intra-cellular dynamic motions.

Monday, 10:30–12:30

Meeting Room 211 A/B

CLEO: Applications & Technology

10:30–12:30
AM2I • Applied Biophotonic Microscopy & Imaging
Presider: David Nolte; Animated Dynamic Inc, USA

AM2I.1 • 10:30 Invited
Towards Anatomical Profiling of Intact Bones with Tissue Clearing, Custom Microscopy and Algorithms, Alon Greenbaum[1,2]; [1]*Joint Dept. of Biomedical Engineering, North Carolina State Univ., USA;* [2]*Joint Dept. of Biomedical Engineering, UNC Chapel Hill, USA.* Bones are complex and vital organs, nevertheless, investigating biological phenomena in the bones is challenging due to their opacity. Bone-CLARITY, a method to render bones transparent allows 3D imaging and analysis of whole mice bone.

AM2I.2 • 11:00 Invited
Adding Dimensions to Intravital Imaging, Scott E. Fraser[1]; [1]*Univ. of Southern California, USA.* Intravital imaging provides a key bridge between molecular & cellular data. To address the compromises in live imaging, we are combining 2-photon light-sheet microscopes for 4D imaging with new multispectral analysis tools to permit rapid and unambiguous 5D analyses of multiplex-labeled specimens.

Meeting Room 211 C/D

CLEO: Science & Innovations

10:30–12:30
SM2J • Optical Computing & Resonator Applications
Presider: Yasutomo Ota; University of Tokyo, Japan

SM2J.1 • 10:30 Invited
Photonic Reservoir Computing in Silicon Photonics, Peter Bienstman[1]; [1]*Ghent Univ., INTEC, Belgium.* Photonic Reservoir Computing is a brain-inspired information processing paradigm that is especially suited for a hardware implementation in photonics. We will present our latest results on a number of applications, ranging from telecom equalization to biological cell sorting.

SM2J.2 • 11:00
All-photonic in-memory computing based on phase-change materials, Carlos Ríos[1,2], Nathan Youngblood[2], Zengguang Cheng[2], Manuel Le Gallo[5], Wolfram Pernice[3], C. David Wright[4], Abu Sebastian[5], Harish Bhaskaran[2]; [1]*MIT (MIT), USA;* [2]*Univ. of Oxford, UK;* [3]*Univ. of Münster, Germany;* [4]*Univ. of Exeter, UK;* [5]*IBM Zürich, Switzerland.* We experimentally demonstrate, for the first time, co-located data storage and processing (i.e. in-memory computing) on an integrated photonic platform based on nonvolatile phase-change materials.

Meeting Room 212 A/B

CLEO: Applications & Technology

10:30–12:30
AM2K • Environmental & Atmospheric Sensing II
Presider: Mark Zondlo; Princeton University, USA

AM2K.1 • 10:30 Invited
Active and Passive Greenhouse Gas Profiling in the Atmosphere Using Near Infrared Tunable Diode Lasers, Houston Miller[1], D. Michelle Bailey[1], Monica M. Flores[1], David Bomse[2]; [1]*Chemistry, George Washington Univ., USA;* [2]*Mesa Photonics, USA.* The development of two laser-based sensors for horizontal and vertical profiling of greenhouse gas levels in the atmosphere including an auto-aligning, open-path instrument and a new variant on laser heterodyne radiometry are presented.

AM2K.2 • 11:00
Simultaneous DIAL, IPDA and point sensor measurements of the greenhouse gases, CO_2 and H_2O, David Plusquellic[2], Gerd Wagner[1], Kimberly Briggman[2], Adam Fleisher[3], David Long[3], Joseph Hodges[3]; [1]*DLR, Germany;* [2]*Physical Measurement Lab, NIST, Boulder, USA;* [3]*Material Measurements Lab, NIST, Gaithersburg, USA.* Rapid scan IPDA and DIAL systems have been developed based on phase modulators for tuning and hybrid counting systems for detection. The performance of these systems has been evaluated through comparisons with point sensor measurements.

Meeting Room 212 C/D

CLEO: Science & Innovations

10:30–12:30
SM2L • Fiber Devices
Presider: Camille-Sophie Bres; Ecole Polytechnique Federale de Lausanne, Switzerland

SM2L.1 • 10:30
Nano-bore fiber focus trap with enhanced performance, Malte Plidschun[1,2], Stefan Weidlich[1,3], Karina Weber[1,4], Martin Šiler[5], Tomáš Čižmár[1,5], Markus Schmidt[1,2]; [1]*Leibniz Inst. of Photonic Technology, Germany;* [2]*Abbe Center of Photonics and Faculty of Physics, FSU Jena, Germany;* [3]*Heraeus Quarzglas GmbH & Co. KG, Germany;* [4]*Inst. of Physical Chemistry, FSU Jena, Germany;* [5]*Inst. of Scientific Instruments, CAS, Czechia.* A novel concept of focus implementation into dual-fiber optical tweezers is presented, enabling a performance increase by >30% for fiber separations <30µm. Simulations are experimentally verified and evaluated using common data processing and fitting routines.

SM2L.2 • 10:45 Invited
Temperature Insensitive Fibers, Radan Slavik[1], Eric Numkam Fokoua[1], Wenwu Zhu[1,2], Meng Ding[1], Tom Bradley[1], Yong Chen[1], Seyed Reza Sandoghchi[1], Marco N. Petrovich[1], Francesco Poletti[1]; [1]*Univ. of Southampton, UK;* [2]*Dalian Univ. of Technology, China.* Hollow core optical fibers guide light through a hole rather than a silica glass. This strongly reduces the light-glass interaction. This gives these fibers many unique properties like low sensitivity to temperature and low non-linearity.

Marriott Salon I & II

CLEO: QELS-Fundamental Science

10:30–12:30
FM2M • Random Numbers & Entanglement
Presider: Josh Nunn; University of Bath, UK

FM2M.1 • 10:30
Interferometric quantum random number generation on chip, Thomas Roger[1], Innocenzo De Marco[1,2], Taofiq Paraiso[1], Davide Marangon[1], Zhiliang Yuan[1], Andrew Shields[1]; [1]*Toshiba Research Europe Limited, UK;* [2]*School of Electronic and Electrical Engineering, Univ. of Leeds, UK.* We demonstrate an on-chip, high-speed quantum random number generator based on the interference of two gain-switched pulsed lasers. FPGA-based electronics allows for real-time processing, providing 8 Gbps random numbers passing all the NIST tests.

FM2M.2 • 10:45
Quantum random number generation (QRNG) by phase diffusion process in a gain-switched semiconductor laser - new insights, Brigitta Septriani[1], Oliver de Vries[1], Markus Graefe[1]; [1]*Fraunhofer Inst. for Applied Optics and Precision Engineering IOF, Germany.* A parametric study of QRNG employing phase diffusion in gain-switched DFB laser diode is presented. New theoretical findings on the maximal raw data rate and explanations on advantage of pulsed regime over cw are given.

FM2M.3 • 11:00 Invited
Using Photons to Generate Certified Randomness, Peter Bierhorst[1]; [1]*Univ. of Colorado at Boulder, USA.* A photonic loophole-free Bell experiment is generating random numbers impossible to predict by any agent that cannot send signals faster than the speed of light. This resource has applications in secure communication.

Marriott Salon III

CLEO: Science & Innovations

10:30–12:30
SM2N • Enhanced Cavities for Sensing and Interferometry
Presider: Denis Donlagic; University of Maribor, Slovenia

SM2N.1 • 10:30 Tutorial
Chipscale Soliton Micro-combs, Tobias J. Kippenberg[1]; [1]*Inst. of Physics, Swiss Federal Inst. of Technology (EPFL), Switzerland.* This tutorial will review the fundamental operational principles and latest development in the field of soliton microresonator frequency combs (micro-combs), which utilize spatio-temporal self organization of light in the form of dissipative solitons. Such microcombs provide chipscale and broadband frequency combs, that have been applied to frequency synthesis, LIDAR, astrophysical spectrometer calibration as well as dual comb based ranging and spectroscopy techniques.

Tobias J. Kippenberg is Full Professor of Physics at EPFL. He obtained his PhD at the California Institute of Technology. From 2005- 2009 he lead an Independent Research Group at the MPI of Quantum Optics. His research interest encompas chipscale optical frequency combs and their applications as well as radiation pressure interaction of laser light and mechanical oscillators. He has received the ICO Prize in Optics (2014), the Swiss National Latsis award (2015) and ZEISS Research Award (2018). He is fellow of the APS and OSA, and listed since 2014 in the Clarivate highlycited.com.

Marriott Salon IV

10:30–12:30
SM2O • Micro & Nano Fabrication
Presider: Tingyi Gu; University of Delaware, USA

SM2O.1 • 10:30
Birefringent Photonic Crystal for High Efficiency Polarization Beam Splitting, Ehsan Ordouie[1], Azad Siahmakoun[1], Hossein Alisafaee[1]; [1]*Physics and Optical Engineering, Rose-Hulman Inst. of Technology, USA.* We have modeled and fabricated a birefringent photonic crystal using only TiO_2. The device demonstrates high efficiency for splitting the polarization states of incident light. The fabrication is done using oblique-angle deposition.

SM2O.2 • 10:45
Curvature-controlled Fabrication of Polymer Nanolens Array, Qiang Li[1], Jaeyoun Kim[1]; [1]*Iowa State Univ., USA.* We demonstrate curvature-controlled fabrication of arrayed nanolenses via UV-assisted modification of photopolymer's material characteristics and elastomer-based nanoimprinting. By varying the UV-dose, the f/# of the 500 nm-diameter nanolens was varied from 1.2 to 10.0.

SM2O.3 • 11:00
High-quality Nanometric Quantum Source: Epitaxially Grown Diamond Nano-pyramids with Silicon-Vacancy Centers, Tzach Jaffe[1], Nina Felgen[2], Lior Gal[1], Lior Kornblum[1], Cyril Popov[2], Johann Peter Reithmaier[2], Meir Orenstein[1]; [1]*Dept. of Electrical Engineering, Technion Israel Inst. of Technology, Israel;* [2]*Inst. of Nanostructure Technologies and Analytics, Univ. of Kassel, Germany.* We present a deterministic template-assisted bottom-up process for creating high-quality nanoscale diamond pyramids incorporating optically active silicon vacancy centers (SiV). We achieved deterministic nano-localization and an extraction efficiency enhancement of 4 compared to bulk diamond.

Executive Ballroom 210A

CLEO: QELS-Fundamental Science

FM2A • Quantum Optics of Atoms and Molecules—Continued

FM2A.4 • 11:15
A Single Shot Measurement of Atomic Coherence in a Thermal Ensemble of Atoms, Arif W. Laskar[1], Niharika Singh[1], Pratik Adhikary[1], Arunabh S. Mukherjee[1], Saikat Ghosh[1]; [1]*Physics, Indian Inst. of Technology, Kanpur, India.* We demonstrate a single shot measurement technique to quantify ground state coherence in atomic system. The quantifier identifies the transition from EIT to Autler-Townes regime. Furthermore, we demonstrate phase coherent control and freezing coherence against decoherence.

FM2A.5 • 11:30
Turning an Organic Molecule into a Coherent Two-Level Quantum System using a Tunable Fabry-Perot Microcavity, Daqing Wang[1], Hrishikesh Kelkar[1], Diego Martin-Cano[1], Dominik Rattenbacher[1], Alexey Shkarin[1], Tobias Utikal[1], Stephan Götzinger[2,1], Vahid Sandoghdar[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Friedrich Alexander Univ. Erlangen-Nuremberg, Germany.* By coupling an organic molecule to a Fabry-Perot microcavity, we turn it into a coherent two-level quantum system. We further demonstrate efficient interaction of this system with single photons generated by a second molecule.

FM2A.6 • 11:45
Raman Scattering Beyond the Master Equation: Photon-Matter Correlations and Statistics, Kai B. Shinbrough[1], Yanting Teng[1], Bin Fang[1], Virginia O. Lorenz[1], Offir Cohen[1]; [1]*Univ of Illinois at Urbana-Champaign, USA.* We present 1D and 3D models that take into account Stokes-photon–excitation pair correlations in Raman scattering, revealing nontrivial dependence of the photon statistics on linewidth, dispersion and collection angle.

Executive Ballroom 210B

Joint

JM2B • Symposium on Nonreciprocal Photonics I—Continued

JM2B.3 • 11:15
Broadband Pulse Delays in Ultracompact Footprints Enabled through Nonreciprocity, Sander Mann[1,3], Dimitrios Sounas[2,3], Andrea Alu[1,3]; [1]*Photonics Initiative, Advanced Science Research Center, USA;* [2]*Electrical and Computer Engineering, Wayne State Univ., USA;* [3]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* We demonstrate large broadband pulse delays in subwavelength structures, enabled through nonreciprocal topologically protected edge states. We develop an equivalent model to study buffer dynamics and accurately predict delays, and demonstrate a new optical resonance.

JM2B.4 • 11:30 Invited
Utilizing Floquet Engineering for the Design of Non-reciprocal Transport, Tsampikos Kottos[1]; [1]*Wesleyan Univ., USA.* We present a framework that lays out the rules under which a periodic driving induces nonreciprocal transport. The method unveils the role of an extended Hilbert space where non-reciprocal Floquet networks can be engineered.

Executive Ballroom 210C

CLEO: QELS-Fundamental Science

FM2C • Nonlinear Nano-Optics—Continued

FM2C.4 • 11:15
Structured Light for Second-Harmonic Spectroscopy in Mie-Resonant AlGaAs Nanoparticles, Elizaveta V. Melik-Gaykazyan[2,1], Kirill Koshelev[1,3], Jae-Hyuck Choi[4], Sergey Kruk[1], Hong-Gyu Park[4], Andrey Fedyanin[2], Yuri S. Kivshar[1]; [1]*Nonlinear Physics Centre, Australian National Univ., Australia;* [2]*Faculty of Physics, Lomonosov Moscow State Univ., Russia;* [3]*ITMO Univ., Russia;* [4]*Dept. of Physics, South Korea Univ., South Korea (the Republic of).* We employ doughnut-shaped cylindrical vector beams to observe the enhanced second-harmonic generation from individual subwavelength AlGaAs nanoparticles which support both electric and magnetic multipolar Mie-type resonances at the fundamental and double frequencies.

FM2C.5 • 11:30
Boosting LSP-enhanced SHG from Au nanoprisms by using NLO polymers, Atsushi Sugita[1], Takumi Makiyama[1], Hikaru Sato[1], Atsushi Ono[1], Wataru Inami[1], Yoshimasa Kawata[1]; [1]*Shizuoka Univ., Japan.* LSP-enhanced SHG from Au nanoprisms surrounded by NLO polymers is presented. Nearly 50-fold increases in LSP-enhanced SHG signals compared to pristine Au nanoprisms are discussed in terms of plasmon-exciton two-photon resonances and molecule-to-metal charge transfer.

FM2C.6 • 11:45
Metal-Dielectric Nanodimers with Hybridized Resonances Probed by Second-Harmonic Polarization, Claude Renaut[1], Lang Lukas[1], Frizyuk Kristina[2], Maria Timofeeva[1], Mihail Petrov[2], Filipp Komissarenko[2], Ivan Mukhin[2], Flavia Timpu[1], Yuri S. Kivshar[3], Rachel Grange[1]; [1]*ETH Zurich, Switzerland;* [2]*ITMO Univ., Russia;* [3]*Australian National Univ., Australia.* We fabricate hybrid nanodimers made of gold and barium titanate nanoparticles by a pick-and-place technique. By overlapping their resonances, we achieve 100-times enhancement of the second-harmonic signal at the hybridized mode while reshaping its polarization.

Executive Ballroom 210D

FM2D • Ultrafast Optical Processes in Topological Materials—Continued

FM2D.2 • 11:30
Ultrafast Photocurrents in the Weyl Semimetal TaAs , Nicholas Sirica[1], Ra'anan Tobey[1], Dmitry Yarotski[1], Pam Bowlan[1], Stuart Trugman[1], Jian-Xin Zhu[1], Yaomin Dai[1], Abul Azad[1], Ni Ni[2], Xianggang Qiu[3], Antoinette Taylor[1], Rohit Prasankumar[1]; [1]*Center for Integrated Nanotechnology, USA;* [2]*Physics and Astronomy, Univ. of California Los Angeles, USA;* [3]*Inst. of Physics Chinese Academy of Science, China.* Terahertz emission from TaAs reveals highly directional, ultrafast photocurrents whose origin is intrinsically due to crystal structure. This is illustrated by unraveling the polarization dependence, directionality, and intrinsic timescales underlying photocurrent generation and decay.

FM2D.3 • 11:45
Spin and Charge Dynamics Across Topological Heterojunction in Monolayer 1T'-WTe_2, Jekwan Lee[1], Wonhyoek Heo[1], Joon Tak[1], Minji Noh[1], Jaeun Eom[2], Changsoo Lee[3], Dohun Kim[2], Hyunyong Choi[1]; [1]*Ultrafast Terahertz Optoelectronics Lab., South Korea (the Republic of);* [2]*Dept. of Physics, Seoul National Univ., South Korea (the Republic of);* [3]*Dept. of Material Science and Engineering, Pohang Univ. of Science and Technology, South Korea (the Republic of).* We studied the ultrafast carrier and spin dynamics on the 1T'-WTe2 monolayer-bilayer interface. Time-resolved optical measurement verified the existence of topological edge state at the continuous interface with weak electron-phonon interaction and long-live electron-electron interaction.

Executive Ballroom 210E | Executive Ballroom 210F | Executive Ballroom 210G | Executive Ballroom 210H

Joint

JM2E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications II—Continued

JM2E.3 • 11:15 Invited
Towards Stable Laser-Plasma Electron Acceleration, Andreas R. Maier[1]; [1]*Univ. of Hamburg, Germany.* Driven by a highly stable laser system, the LUX accelerator combines expertise in plasma and conventional accelerator technology. We report on the generation of few-nm undulator radiation and stable operation of the LUX plasma accelerator.

JM2E.4 • 11:45
Supercontinuum-seeded, CEP-stable, high-power 4-micron KTA OPA driven by a 1.4-ps Yb:YAG thin-disk laser and its application to high harmonic generation, Tsuneto Kanai[1,2], Yeon Lee[1,2], Meenkyo Seo[1,2], Dong E. Kim[1,2]; [1]*Max Planck Center for Attosecond Science, South Korea (the Republic of);* [2]*Physics, Postech, South Korea (the Republic of).* We demonstrate a supercontinuum-seeded, phase-stable, 17-W mid-IR KTA OPA driven by a 1.4-ps Yb:YAG thin-disk laser. The seeding scheme simplifies the architecture and its performance is demonstrated by sensitive detection of photon signals from ZnSe.

CLEO: Science & Innovations

SM2F • Quantum Sensing in Solid State Systems—Continued

SM2F.3 • 11:15
Quantum Sensing in CMOS under Ambient Conditions: On-Chip Detection of Electronic Spin States in Diamond, Christopher Foy[1], Mohamed Ibrahim[1], Donggyu Kim[1], Dirk R. Englund[1], Ruonan Han[1], Matthew Trusheim[1]; [1]*MIT, USA.* We demonstrate the first on-chip NV ODMR for quantum sensing, which combines the compactness of CMOS integrated circuit technologies with nitrogen-vacancy (NV) centers in diamond.

SM2F.4 • 11:30 Invited
Creating Highly Coherent NV Centers in Diamond, Ania Bleszynski Jayich[1], Claire McLellan[1], Tim Eichhorn[1], Simon Meynell[1]; [1]*Univ. of California Santa Barbara, USA.* The diamond NV center is a powerful platform for diverse quantum applications. We present novel NV formation techniques, using CVD diamond growth and tunable electron irradiation, that optimize the quantum properties of NV spin ensembles.

SM2G • Free-Space & Underwater Communication—Continued

SM2G.4 • 11:30
Hybrid Femtocell-Attocell Optical Links for High-Speed Indoor Wireless Network, Spencer Liverman[1], Siyuan Chen[1], Arun Natarajan[1], Thinh Nguyen[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* A dual channel indoor optical link is presented consisting of a 100Mbps wide-angle femtocell and a 1.5Gbps line-of-sight attocell. Wavelength multiplexing is used to eliminate interference between the two spatially overlapped optical links.

SM2G.5 • 11:45
Optical Broadcasting for Wide Field-of-View Bidirectional Indoor Optical Wireless Communications, Feng Feng[1], Paramin Sangwongngam[1], Hyunchae Chun[1], Grahame Faulkner[1], Dominic O'Brien[1]; [1]*Univ. of Oxford, UK.* We demonstrate point-to-multipoint optical wireless upstream and downstream data transmission at 12.5Gb/s between a novel holographic beam steering base station with ±30° FOV and two nomadic terminals that use mirror-based steering with ±50° FOV.

SM2H • Optical Imaging & Sensing—Continued

SM2H.4 • 11:15
All-optical Hilbert transform with optical frequency comb for one-shot three-dimensional imaging, Takashi Kato[1,2], Megumi Uchida[1,2], Yurina Tanaka[1,2], Kaoru Minoshima[1,2]; [1]*The Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan.* A novel all-optical Hilbert transform with precise relative carrier-phase and envelope control utilizing frequency control of an optical frequency comb is reported. One-shot three-dimensional imaging of a surface profile demonstrated 200-square-pixels resolution and μm-level uncertainty.

SM2H.5 • 11:30
Cascade-Linked Multi-Synthetic-Wavelength Digital Holography Using Line-by-Line Spectral Shaping Optical Frequency Comb, Takeshi Yasui[1,2], Masatomo Yamagiwa[1,2], Takeo Minamikawa[1,2], Isao Morohashi[3], Norihiko Sekine[3], Iwao Hosako[3], Hirotsugu Yamamoto[4]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan;* [3]*National Inst. of Information and Communications Technology, Japan;* [4]*Utsunomiya Univ., Japan.* Line-by-line spectral shaping of a 10-GHz optical frequency comb (OFC) is used for cascade-linked multi-synthetic-wavelength digital holography. The proposed method enables the real-time 3D shape measurement with wide axial dynamic range.

SM2H.6 • 11:45
Depth thermography enabled by precise thermal-emission measurements, Yuzhe Xiao[1], Chenghao Wan[1], Alireza Shahsafi[1], Jad Salman[1], Mikhail Kats[1]; [1]*Univ. of Wisconsin-Madison, USA.* We developed and experimentally demonstrated a depth-thermography technique based on infrared thermal emission that enables the extraction of temperatures beneath the surface of an object.

Meeting Room 211 A/B

CLEO: Applications & Technology

AM2I • Applied Biophotonic Microscopy & Imaging—Continued

AM2I.3 • 11:30
Holographic Reconstruction with Bright-field Microscopy Contrast using Cross-Modality Deep Learning, Yilin Luo[1], Yichen Wu[1], Gunvant Chaudhari[2], Yair Rivenson[1], Ayfer Calis[1], Kevin Haan[1], Aydogan Ozcan[1,2]; *[1]Electrical and Computer Engineering Dept., Univ. of California, Los Angeles, California, USA; [2]David Geffen School of Medicine, Univ. of California, Los Angeles, USA.* Deep learning-based holographic reconstruction method eliminates twin-image, speckle and other interference artifacts at the output image, matching the contrast of bright-field microscopy, and merges volumetric imaging capability of holography with the contrast of incoherent microscopy.

AM2I.4 • 11:45
Spectral Phase and Amplitude Retrieval and Compensation for Random Access Microscopy, Alyssa M. Allende Motz[1], Charles G. Durfee[1], Jeff Squier[1], Danial Adams[1]; *[1]Colorado School of Mines, USA.* Programmable, two-dimensional, spatial frequency modulation linear and nonlinear imaging combined with a novel and remarkably simple, in-situ quantitative pulse compensation and measurement scheme is demonstrated for the first time.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM2J • Optical Computing & Resonator Applications—Continued

SM2J.3 • 11:15
High-resolution Silicon Microring based Architecture for Optical Matrix Multiplier, Natalie Janosik[1], Qixiang Cheng[1], Madeleine Glick[1], Yishen Huang[1], Keren Bergman[1]; *[1]Columbia Univ., USA.* We characterize silicon photonic microring resonators specifically designed with low Quality Factors (Q) to operate with high linearity measured over a range of 1.44 volts suitable for microring-based high resolution optical matrix multiplier architectures.

SM2J.4 • 11:30
Photonic Crystal Design with Mix and Match Unit Cells for Mode Manipulation, Sami I. Halimi[1], Zhongyuan Fu[1,3], Francis O. Afzal[1], Joshua Allen[2], Shuren Hu[4], Sharon M. Weiss[1,2]; *[1]Dept. of Electrical Engineering and Computer Science, Vanderbilt Univ., USA; [2]Interdisciplinary Graduate Program in Materials Science, Vanderbilt Univ., USA; [3]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China; [4]Dept. of Physics and Astronomy, Vanderbilt Univ., USA.* We report simulations and experimental measurement of a photonic crystal designed with mix and match unit cells. Our results enable extreme mode manipulation and potentially also phase and amplitude modification using non-traditional unit cell shapes.

SM2J.5 • 11:45
Directional Asymmetry in Biphoton Correlations, Austin J. Graf[1], Jeremy Staffa[1], Dana Griffith[2], Steven D. Rogers[1], Usman A. Javid[1], Qiang Lin[1]; *[1]Univ. of Rochester, USA; [2]Wellesley College, USA.* We have demonstrated asymmetry in biphoton coherence functions that arises upon reversing the propagation direction of a pump laser coupled into a silicon microdisk. Oscillations in the coherence functions experience an almost total phase shift.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM2K • Environmental & Atmospheric Sensing II—Continued

AM2K.3 • 11:30
Label-free Bio-aerosol Sensing Using On-Chip Holographic Microscopy and Deep Learning, Yichen Wu[1], Ayfer Calis[1], Yi Luo[1], Cheng Chen[1], Maxwell Lutton[1], Yair Rivenson[1], Xing Lin[1], Hatice Ceylan Koydemir[1], Yibo Zhang[1], Hongda Wang[1], Zoltán Göröcs[1], Aydogan Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* We present automated and label-free bio-aerosol sensing using a portable and cost-effective device, enabled by on-chip digital holographic microscopy and deep-learning.

AM2K.4 • 11:45
Open-Path Mid-Infrared Remote Sensing of Atmospheric Gases Using a Broadband Optical Parametric Oscillator, Oguzhan Kara[1], Frazer Sweeney[1], Marius Rutkauskas[1], Carl Farrell[2], Christopher Leburn[2], Derryck Reid[1]; *[1]Heriot Watt Univ., UK; [2]Chromacity Ltd., UK.* Using active Fourier-transform spectroscopy with a mid-infrared ultrafast optical parametric oscillator we demonstrate quantitative, open-path, simultaneous concentration measurements of water, methane and ethane at over 30-m range with a simple target.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM2L • Fiber Devices—Continued

SM2L.3 • 11:15
Fabrication of Near-Field Optical Fiber Probes Through Focused Ion Beam, Karen Sloyan[1], Henrik Melkonyan[1], Matteo Chiesa[1], Marcus Dahlem[2,1]; *[1]Khalifa Univ., United Arab Emirates; [2]InterUniv. Microelectronics Center (IMEC), Belgium.* We describe a procedure to fabricate a near-field optical fiber probe using focused ion beam milling. The method allows to control the fiber taper angle for better throughput, and the taper length for mechanical robustness.

SM2L.4 • 11:30
Low-Loss Ring-Core Fiber Supporting 4 Mode Groups, Heyun Tan[2], Junwei Zhang[1], Jie Liu[1], Lei Shen[3], Guoxuan Zhu[1], Rui Zhang[3], Yaping Liu[3], Lei Zhang[3], Siyuan Yu[1,4]; *[1]School of Electronics and Information Engineering, State Key Lab of Optoelectronic Materials and Technologies, Sun Yat-sen Univ., China; [2]School of Physics, State Key Lab of Optoelectronic Materials and Technologies, Sun Yat-sen Univ., China; [3]State key Lab of Optical Fiber and Cable Manufacture technology, Yangtze Optical Fiber and Cable Joint Stock Limited Company, China; [4]Photonics Group, Merchant Venturers School of Engineering, Univ. of Bristol, UK.* A ring-core fiber with a novel modulated-refractive-index profile is reported, whose low attenuation (~0.2 dB/km) and low inter-mode-group coupling coefficient (<-36 dB/km for adjacent high-order mode groups), both setting records for a ring-core fiber.

SM2L.5 • 11:45
Poling Optical Fibers with UV Lamp, João Manoel B. Pereira[1,2], Alexandre R. Camara[3,4], Fredrik Laurell[2], Oleksandr Tarasenko[1], Walter Margulis[1,2]; *[1]Fiber Optics, RISE Acreo, Sweden; [2]Applied Physics, Royal Inst. of Technology, Sweden; [3]Instituto de física, Universidade do Estado do Rio de Janeiro, Brazil; [4]Programa de Pós-Graduação em Engenharia Eletrônica, Universidade do Estado do Rio de Janeiro, Brazil.* Silicate fibers with internal electrodes are optically poled without a laser by side-exposure to radiation from a UV tubular lamp. Electrooptic coefficients $\chi^{(2)} \sim 0.04$ pm/V and $V_\pi = 810$ V are obtained.

Marriott
Salon I & II

Marriott
Salon III

Marriott
Salon IV

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

FM2M • Random Numbers & Entanglement—Continued

FM2M.4 • 11:30
Symmetrical Bell state preparation and measurement without a third party, Yong-Su Kim[1,2], Tanumoy Pramanik[1], Young-Wook Cho[1], Ming Yang[3], Sang-Wook Han[1], Sang-Yun Lee[1], Min-Sung Kang[1], Sung Moon[1,2]; [1]*South Korea Inst. of Science & Technology, South Korea (the Republic of);* [2]*South Korea Univ. of Science and Technology, South Korea (the Republic of);* [3]*Anhui Univ., China.* We present a linear optical Bell state preparation and measurement schemes without photon-photon interaction at an optical element. Unlike the standard schemes, it can be symmetrically divided into two parties without a third party.

FM2M.5 • 11:45
Violating Bell inequalities with entangled optical frequency combs and multi-pixel homodyne detection, William N. Plick[1], Franceso Arzani[2], Nicolas Treps[2], Damian Markham[2], Eleni Diamanti[2]; [1]*Univ. of Dayton, USA;* [2]*Sorbonne Universites, France.* We theoretically investigated using continuous-variable Bell-type inequalities in a multiparty configuration using an optical parametric oscillator which has been synchronously-pumped with a frequency comb. We find violation is possible.

SM2N • Enhanced Cavities for Sensing and Interferometry—Continued

SM2N.2 • 11:30
Frequency Comb phase-locked Cavity Ringdown Spectroscopy, Zachary D. Reed[1], Joseph Hodges[1]; [1]*NIST, USA.* We present a frequency comb phase-locked cavity ringdown spectrometer capable of arbitrary frequency steps with 1 kHz absolute frequency accuracy, and demonstrate determination of molecular line positions with better than 40 kHz accuracy.

SM2N.3 • 11:45
Attenuated Total Reflectance Dual-Comb Spectroscopy of an Organic Liquid-Phase Chemical Reaction, Daniel I. Herman[1,2], Eleanor Waxman[1], Gabriel Ycas[1,2], Fabrizio R. Giorgetta[1,2], Nathan R. Newbury[1], Ian Coddington[1]; [1]*NIST, USA;* [2]*Physics, Univ. of Colorado Boulder, USA.* A mid-infrared dual-comb spectrometer coupled to an attenuated total reflectance cell is used to monitor the hydration of mesityl oxide (MO) into diacetone alcohol (DAA). Our method provides real-time concentrations for MO and DAA.

SM2O • Micro & Nano Fabrication—Continued

SM2O.4 • 11:30
Light-Directed Nanomanipulation of Colloidal Particles in Ambient Environments, Jingang Li[1], Yaoran Liu[1], Yuebing Zheng[1]; [1]*The Univ. of Texas at Austin, USA.* We report an all-optical technique for the versatile nanomanipulation of various colloidal particles under ambient conditions by harnessing both photothermal effects and optical forces.

SM2O.5 • 11:45
Improvement of lasing threshold of ink-jet printed polymeric microdisk cavity by precise controlled wet etching, Taku Takagishi[1], Hiroaki Yoshioka[1], Yuya Mikami[1], Naoya Nishimura[2], Yuji Oki[1]; [1]*Kyushu Univ., Japan;* [2]*Nissan Chemical Corporation, Japan.* With well-controlled wet etching process, under-cut structure of ink-jet printed microdisk was successfully formed and we succeeded in lowering the lasing threshold by 10 times, compared with the one on a substrate.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D
CLEO: QELS-Fundamental Science	Joint	CLEO: QELS-Fundamental Science	

Monday, 10:30–12:30

FM2A • Quantum Optics of Atoms and Molecules—Continued

FM2A.7 • 12:00
Quantum Few-body Dynamics of Rydberg Atom Clusters, Woojun Lee[1], Minhyuk Kim[1], Hanlae Jo[1], Yunheung Song[1], Jaewook Ahn[1]; [1]*Dept. of Physics, South Korea Advanced Inst. of Science and Technology, South Korea (the Republic of).* We model and experimentally verify the quantum dynamics of small-scale Rydberg-atom quantum simulators, or entangled Rydberg atom clusters, using Lindblad equations with control parameters including spontaneous emission, stochastic atom loss, and laser phase noise.

FM2A.8 • 12:15
Interferometric implementation of Rydberg-atom entanglements, Hanlae Jo[1], Yunheung Song[1], Minhyuk Kim[1], Jaewook Ahn[1]; [1]*Physics, South Korea Advanced Inst of Science & Tech, South Korea (the Republic of).* We propose and experimentally demonstrate interferometrically controlled Rydberg-atom entanglements, for atoms separated farther than their blockade radius, where the interaction phase induced during the time interval between two control pulses implements distance-selective atom-atom entanglement.

JM2B • Symposium on Nonreciprocal Photonics I—Continued

JM2B.5 • 12:00 Invited
Topological Quantum Photonics, Edo Waks[1], Mohammad Hafezi[1], Sabyasachi Barik[1], Shuo Sun[2], Aziz Karasahin[1], Chris Flower[1]; [1]*Univ. of Maryland at College Park, USA;* [2]*Stanford Univ., USA.* I will describe our work towards developing quantum photonic devices that exhibit strong topological properties such as robust edge states and chiral light-matter interactions.

FM2C • Nonlinear Nano-Optics—Continued

FM2C.7 • 12:00
Tunable Resonator-Upconverted Emission (TRUE) Color Prints for Anti-counterfeiting Applications, Hailong Liu[1], Jiahui Xu[2], Hao Wang[1], Xiaogang Liu[2], Joel K. W. Yang[1]; [1]*Singapore Univ. of Technology & Design, Singapore;* [2]*National Univ. of Singapore, Singapore.* We fabricated gap-plasmon resonators with self-assembled upconversion nanoparticles embedded within to simultaneously achieve size-tunable plasmonic and emissive colors and demonstrated tunable resonator-upconverted emission (TRUE) color prints for anti-counterfeiting applications.

FM2D • Ultrafast Optical Processes in Topological Materials—Continued

FM2D.4 • 12:00
Optoelectronic Valley-locked Spin Photocurrent Generation using WSe_2-Bi_2Se_3 Heterostructure, Minji Noh[1], Soonyoung Cha[2], Jehyun Kim[3], Yoomin Kim[1], Jekwan Lee[1], Hoil Kim[2], Seunghoon Yang[4], Sooun Lee[1], Wooyoung Shim[1], Chul-Ho Lee[4], Jun Sung Kim[2], Dohun Kim[3], Hyunyong Choi[1]; [1]*Yonsei Univ., South Korea (the Republic of);* [2]*Pohang Univ. of Science and Technology, South Korea (the Republic of);* [3]*Seoul National Univ., South Korea (the Republic of);* [4]*South Korea Univ., South Korea (the Republic of).* We demonstrate a new optoelectronic platform using WSe_2-Bi_2Se_3 heterostructures to generate and detect the valley-coupled spin-polarized photocurrents at room temperature. The light polarization and the external electric field can manipulate the magnitude of the current.

FM2D.5 • 12:15
Electric Control over 2D Dirac Plasmon Resonances in Topological Insulator Bi_2Se_3 in Proximity Contact with Graphene, Chihun In[1], Beom Kim[1], Jisoo Moon[2], Seung Young Seo[3], Woosun Jang[1], Hyunseung Jung[4], Myungwoo Son[5], Seongshik Oh[2], Aloysius Soon[1], Hojin Lee[4], Moon-Ho Ham[5], Hyunyong Choi[1]; [1]*Yonsei Univ. , South Korea (the Republic of);* [2]*Rutgers Univ., USA;* [3]*Pohang Univ. of Science and Technology, South Korea (the Republic of);* [4]*Soongsil Univ., South Korea (the Republic of);* [5]*Gwangju Inst. of Science and Technology, South Korea (the Republic of).* Graphene and topological insulator (TI) host two-dimensional (2D) Dirac surface plasmon at the terahertz frequency range. We observed unconventional density-dependence of 2D topological Dirac plasmon upon in proximity to the monolayer graphene.

12:30–13:30 Lunch Break (on your own)

12:30–13:30 What's Next in Integrated Optics – Hot Topics at CLEO: 2019, *Room 230A*

13:00–14:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

13:00–14:00 Social Media in 2019 Panel Discussion, *University Room, Hilton San Jose*

13:30–17:30 SC362: Cavity Optomechanics: Fundamentals and Applications (Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland*)
SC376: Plasmonics (Mark Brongersma; *Stanford Univ., USA*)
SC378: Introduction to Ultrafast Optics (Rick Trebino, *Georgia Institute of Technology, USA*)
SC476: QCL and QCL Combs (Jérôme Faist, *ETH Zürich, Switzerland*)

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H
Joint	CLEO: Science & Innovations		

JM2E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications II—Continued

JM2E.5 • 12:00 Invited
Multi-Wavelength Laser Control of High-Voltage Discharges: From the Lab to Säntis Mountain, Thomas Proruit[1], Guillaume Schimmel[1], Elise Schubert[1], Denis Mongin[1], Ali Rastegari[2], Chengyong feng[2], Brian Kamer[2], Ladan Arissian[2], Jean-Claude Diels[2], Pierre Walch[2], Benoît Mahieu[3], Yves-Bernard andre[3], Aurelien Houard[3], Clemens Herkommer[4], Robert Jung[4], Thomas Metzger[4], Knut Michel[4], André Mysyrowicz[5], Jean-Pierre Wolf[1], Jerome Kasparian[1]; [1]*Univ. of Geneva, Switzerland;* [2]*Univ. of New Mexico, USA;* [3]*LOA, ENSTA ParisTech, France;* [4]*TRUMPF Scientific lasers GmbH, Germany;* [5]*André Mysyrowicz Consultants, France.* We review recent results on multi-wavelength multipulse schemes to control high-voltage discharges with ultrashort pulses, and discuss their implications on lightning control at atmospheric scale.

SM2F • Quantum Sensing in Solid State Systems—Continued

SM2F.5 • 12:00
Anti-Stokes Excitation of Solid-State Quantum Emitters for Nanoscale Thermometry, Trong Toan Tran[1], Blake Regan[1], Evgeny Ekimov[2], Zhao Mu[3], Zhou Yu[3], Weibo Gao[3], Prineha Narang[4], Alexander Solntsev[1], Milos Toth[1], Igor Aharonovich[1], Carlo Bradac[1]; [1]*School of Mathematical and Physical Sciences, Univ. of Technology Sydney, Australia;* [2]*Physics, Inst. for High Pressure Physics, Russia;* [3]*Physics and Applied Physics, Nanyang Technological Univ., Singapore;* [4]*John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA.* We report the first demonstration of Anti-Stokes excitation on a single solid-state quantum emitter—namely the germanium-vacancy center in diamond and its application as a high-sensitive nanoscale thermal sensor.

SM2F.6 • 12:15
4H-SiC-on-Insulator Platform for Quantum Photonics, Daniil Lukin[1], Constantin Dory[1], Marina Radulaski[1], Shuo Sun[1], Sattwik Deb Mishra[1], Melissa Guidry[1], Dries Vercruysse[1], Jelena Vuckovic[1]; [1]*Electrical Engineering, Stanford Univ., USA.* We present a 4H-Silicon-Carbide-on-Insulator platform that enables versatile integration of color centers with photonic devices.

SM2G • Free-Space & Underwater Communication—Continued

SM2G.6 • 12:00
60m/2.5Gbps Underwater Optical Wireless Communication with NRZ-OOK Modulation and Digital Nonlinear Equalization, Chunhui Lu[1], Jiemei Wang[1], Shangbin Li[1], Zhengyuan Xu[1]; [1]*Univ. of Science and Technology, China.* We experimentally demonstrate a 2.5Gbps communication system based on a 450nm laser over 60m underwater transmission distance at the BER level of 3.5×10^{-3} by using NRZ-OOK modulation and digital nonlinear equalization technology.

SM2H • Optical Imaging & Sensing—Continued

SM2H.7 • 12:00
All-fiber reflection-based scattering NSOM with low phase drift for guided-wave imaging on a chip, Yizhi Sun[1,2], Binbin Wang[3], Rafael Salas-Montiel[3], Sylvain Blaize[3], Renaud Bachelot[3], Wei Ding[1]; [1]*CAS Inst. of Physics, China;* [2]*Beihang Univ., China;* [3]*Université de Technologie de Troyes, France.* An all-fiber phase-resolved reflection-based near-field scanning optical microscope with a phase-drift-rate of 0.06°/s is developed. By raster scanning atomic force microscope probe, we measure the complex near-fields and analyze the standing-wave-spectrograms in silicon nano-waveguides.

SM2H.8 • 12:15
Orbital Angular Momentum-resolved Dual-comb Spectroscopy towards Topological Material Studies, Akifumi Asahara[1,2], Takuto Adachi[1], Yue Wang[1,2], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan.* Orbital angular momentum-resolved dual-comb spectroscopy towards topological material studies is demonstrated. The developed method is a new type of multi-dimensional interferometric comb spectroscopy, generalizing longitudinal and transverse optical modes.

12:30–13:30 Lunch Break (on your own)

12:30–13:30 What's Next in Integrated Optics – Hot Topics at CLEO: 2019, *Room 230A*

13:00–14:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

13:00–14:00 Social Media in 2019 Panel Discussion, *University Room, Hilton San Jose*

13:30–17:30 SC362: Cavity Optomechanics: Fundamentals and Applications (Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland***)**
SC376: Plasmonics (Mark Brongersma; *Stanford Univ., USA***)**
SC378: Introduction to Ultrafast Optics (Rick Trebino, *Georgia Institute of Technology, USA***)**
SC476: QCL and QCL Combs (Jérôme Faist, *ETH Zürich, Switzerland***))**

Monday, 10:30–12:30

Meeting Room 211 A/B

CLEO: Applications & Technology

AM2I • Applied Biophotonic Microscopy & Imaging—Continued

AM2I.5 • 12:00
Computation-enabled Lensless Imaging & Deep-Brain Microscopy, Brian Rodriguez[1], Zhimeng Pan[1], Ruipeng Guo[1], Naveen Nagarajan[1], Kyle Jenks[1], Mario Capecchi[1], Jason Sheperd[1], Rajesh Menon[1]; [1]*Univ. of Utah, USA.* We show imaging using only a CMOS image sensor, and fluorescence microscopy inside the mouse brain using a surgical needle and an image sensor, both enabled by computation including machine learning.

AM2I.6 • 12:15
Enhancing Resolution in Coherent Microscopy Using Deep Learning, Tairan Liu[1], Kevin Haan[1], Yair Rivenson[1], Zhensong Wei[1], Xin Zeng[1], Yibo Zhang[1], Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* A generative adversarial network (GAN) based super-resolution framework is presented. This deep learning-based framework is capable of enhancing the resolution of coherent imaging systems in both pixel size-limited and diffraction-limited microscopy systems.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM2J • Optical Computing & Resonator Applications—Continued

SM2J.6 • 12:00
Ultrahigh-*Q/V* single cell slotted nanocavity operated in water, Eiichi Kuramochi[1], Théo Martel[1], Shota Kita[1], Hideaki Taniyama[1], Akihiko Shinya[1], Masaya Notomi[1]; [1]*NTT Corporation, Japan.* By tuning 30 or more holes, H1 slotted nanocavities with theoretical *Q* exceeding 10^5 and mode volume smaller than 0.03 $(\lambda/n)^3$ in water were designed. A *Q* factor exceeding 10^4 was measured in ultrapure water.

SM2J.7 • 12:15
Resonant-Cavity Infrared Detector (RCID) with Very Thin Absorber, Chadwick Canedy[1], William W. Bewley[1], Charles Merritt[1], Chul Soo Kim[1], Mijin Kim[2], Stephanie Tomasulo[1], Michael V. Warren[3], Eric M. Jackson[1], Jill A. Nolde[1], Chaffra A. Affouda[1], Edward H. Aifer[1], Igor Vurgaftman[1], Jerry R. Meyer[1]; [1]*Naval Research Lab, USA;* [2]*KeyW, USA;* [3]*ASEE Postdoctoral Fellow, USA.* A resonant-cavity detector with peak sensitivity at 4.0 μm reaches 34% external quantum efficiency at room temperature, despite having only five absorbing quantum wells. Multiple passes enhance the peak absorption by nearly 30x.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM2K • Environmental & Atmospheric Sensing II—Continued

AM2K.5 • 12:00 Invited
MIRA: A New, Ultrasensitive, Middle Infrared Laser-Based Gas Analyzer for Environmental Monitoring Applications. James J. Scherer[1], Joshua B. Paul[1], Jerome Thiebaud[1], and Stephen So[1]. [1]*Aeris Technologies, Inc., USA.* A new, ultrasensitive lunchbox-sized middle infrared laser-based commercial gas sensor is described, with examples of monitoring key pullutants (CO, HCHO), greenhouse gases (CH^4, N^2O) with [1]ppb accuracy levels in a variety of field applications.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM2L • Fiber Devices—Continued

SM2L.6 • 12:00
The thermal sensitivity of optical path length in standard single mode fibers down to cryogenic temperatures, Wenwu Zhu[1,2], Meng Ding[2], Mingshan Zhao[1], David Richardson[2], Radan Slavik[2]; [1]*Dalian Univ. of Technology, China;* [2]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We measured the thermal sensitivity of SMF-28 fiber in the range -190°C - 25°C and measured a > 3-fold decrease for uncoated fiber towards the lowest measured temperature and far higher sensitivities for coated and jacketed fibers.

12:30–13:30 Lunch Break (on your own)

12:30–13:30 What's Next in Integrated Optics – Hot Topics at CLEO: 2019, *Room 230A*

13:00–14:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

13:00–14:00 Social Media in 2019 Panel Discussion, *University Room, Hilton San Jose*

13:30–17:30 SC362: Cavity Optomechanics: Fundamentals and Applications (Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland***)**
SC376: Plasmonics (Mark Brongersma; *Stanford Univ., USA***)**
SC378: Introduction to Ultrafast Optics (Rick Trebino, *Georgia Institute of Technology, USA***)**
SC476: QCL and QCL Combs (Jérôme Faist, *ETH Zürich, Switzerland***)**

Marriott Salon I & II	Marriott Salon III	Marriott Salon IV

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

FM2M • Random Numbers & Entanglement—Continued

FM2M.6 • 12:00
Withdrawn

FM2M.7 • 12:15
Verifying Multi-Partite Entanglement with a Few Detection Events, Lee Rozema[1], Valeria Saggio[1], Aleksandra Dimic[2], Chiara Greganti[1], Philip Walther[1], Borivoje Dakic[1]; [1]*Univ. of Vienna, Austria;* [2]*Univ. of Belgrade, Serbia.* We introduce a new entanglement-verification method and use it to experimentally verify the entanglement in a photonic six-qubit cluster state, created at telecommunication wavelengths, by detecting only 20 copies of the quantum state.

SM2N • Enhanced Cavities for Sensing and Interferometry—Continued

SM2N.4 • 12:00
Trace Gas Sensing through Purcell-Enhanced Raman Scattering in Pressurized Microcavities, Juan S. Gomez Velez[1], Andreas Muller[1]; [1]*Univ. of South Florida, USA.* Minimally long microcavities were constructed for Purcell-enhanced Raman scattering in gases at up to 12 bar pressure. A linear emission rate confirms pressure broadening remains exceeded by the cavity linewidth, making pressurization beneficial.

SM2N.5 • 12:15
Near-Infrared Continuous-Filtering Vernier Spectroscopy in a Flame, Chuang Lu[1], Francisco Senna Vieira[1], Florian M. Schmidt[2], Aleksandra Foltynowicz[1]; [1]*Dept. of Physics, Umeå Univ., Sweden;* [2]*Dept. of Applied Physics and Electronics, Umeå Univ., Sweden.* A continuous-filtering Vernier spectrometer based on an Er:fiber femtosecond laser was developed to acquire broadband H_2O and OH spectra in a premixed CH_4/air flame with 25 ms time resolution and percent precision on concentrations retrieval.

SM2O • Micro & Nano Fabrication—Continued

SM2O.6 • 12:00
High Quality Factor PECVD Si_3N_4 Ring Resonators Compatible with CMOS Process, Xingchen Ji[1,2], Samantha Roberts[1], Michal Lipson[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA.* We demonstrate high-confinement Si_3N_4 resonators with intrinsic quality factor more than 1 million using standard PECVD process. We show that by addressing scattering, the loss at 1.6 µm can be as low as 0.4 dB/cm.

SM2O.7 • 12:15
Fabrication of High-Q, High-Confinement 4H-SiC Microring Resonators by Surface Roughness Reduction, Yi Zheng[1], Minhao Pu[1], Ailun Yi[2], Ayman N. Kamel[1], Martin R. Henriksen[3], Asbjørn A. Jørgensen[3], Xin Ou[2], Haiyan Ou[1]; [1]*Technical Univ. of Denmark, Denmark;* [2]*Inst. of Microsystem and Information Technology, Chinese Academy of Sciences, China;* [3]*Niels Bohr Inst., Univ. of Copenhagen, Denmark.* We improve the Q of SiC microring resonators with a sub-micron cross-sectional dimension by a factor of six by reducing surface roughness. We achieve a high Q (~73,000) for such a device with anomalous dispersion.

12:30–13:30 Lunch Break (on your own)

12:30–13:30 What's Next in Integrated Optics – Hot Topics at CLEO: 2019, *Room 230A*

13:00–14:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

13:00–14:00 Social Media in 2019 Panel Discussion, *University Room, Hilton San Jose*

13:30–17:30 SC362: Cavity Optomechanics: Fundamentals and Applications (Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland***)**
SC376: Plasmonics (Mark Brongersma; *Stanford Univ., USA***)**
SC378: Introduction to Ultrafast Optics (Rick Trebino, *Georgia Institute of Technology, USA***)**
SC476: QCL and QCL Combs (Jérôme Faist, *ETH Zürich, Switzerland***)**

Executive Ballroom 210A

CLEO: QELS-Fundamental Science

13:30–15:30
FM3A • Quantum Nanophotonics I: Plasmonics & Quantum Dots
Presider: Kai-Mei Fu; University of Washington, USA

FM3A.1 • 13:30
Voltage controlled fine-structure splitting of single photon emitters in a two-dimensional semiconductor, Chitraleema Chakraborty[2,1], Nicholas Jungwirth[3], Gregory Fuchs[3], Nick Vamivakas[4]; *[1]Electrical Engineering and Computer Science, MIT, USA; [2]Materials Science, Univ. of Rochester, USA; [3]School of Applied and Engineering Physics, Cornell Univ., USA; [4]The Inst. of Optics, Univ. of Rochester, USA.* We report on the modulation of the fine-structure splitting (FSS) of quantum dot-like emitters in a two-dimensional semiconductor. Voltage-controlled suppression of the electron-hole exchange interaction features a 40% increase in circular polarization with decreasing FSS.

FM3A.2 • 13:45
Generation of quantum light in a photon-number superposition, Carlos Antón Solanas[1,2], Juan Carlos Loredo[1,2], Bogdan Reznychenko[3,4], Paul Hilaire[1,2], Abdelmounaim Harouri[1,2], Clement Millet[1,2], Helene Ollivier[1,2], Niccolo Somaschi[5], Lorenzo de Santis[1,2], Aristide Lemaitre[1,2], Isabelle Sagnes[1,2], Loic Lanco[1,6], Alexia Auffeves[3,4], Olivier Krebs[1,2], Pascale Senellart[1,2]; *[1]CNRS Center of Nanosciences and Nanotechnology, France; [2]Universite Paris-Sud, Universite Paris-Saclay, France; [3]CNRS Institut Neel, France; [4]Univ. Grenoble Alpes, France; [5]Quandela, SAS, France; [6]Université Paris Diderot, France.* We generate highly pure quantum states of light in a coherent superposition of zero, one, and two photons. Such states are generated by coherently driving electrically-controlled QD-microcavity devices with resonant laser pulses.

FM3A.3 • 14:00
A Charge-Tunable Quantum Dot Strongly Coupled to a Nanophotonic Cavity, Zhouchen Luo[2], Allan S. Bracker[1], Dan Gammon[1], Edo Waks[2]; *[1]Naval Research Lab, USA; [2]Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, USA.* We report for the first time a strong interface between a charge tunable quantum dot spin and a microcavity embedded in a p-i-n-i-n diode structure, which enables control and stabilization of quantum dots charging state.

Executive Ballroom 210B

Joint

13:30–15:30
JM3B • Symposium on Nonreciprocal Photonics II
Presider: To Be Announced

JM3B.1 • 13:30 Invited
Brillouin Based Non-reciprocal Functions for On-chip Optical Signal Processing, Benjamin J. Eggleton[1]; *[1]Univ. of Sydney, Australia.* Stimulated Brillouin Scattering is an efficient opto-mechanical process that generates a sound-wave in an optical waveguide; the direction of the travelling sound wave breaks time-reversal symmetry, enabling non-reciprocity, the basis of isolators and circulators.

JM3B.2 • 14:00
Experimental band structure spectroscopy along the synthetic dimension, Avik Dutt[1], Momchil Minkov[1], Qian Lin[1], Luqi Yuan[2,1], David A. Miller[1], Shanhui Fan[1]; *[1]Stanford Univ., USA; [2]Shanghai Jiao Tong Univ., China.* We propose the first technique to directly measure the band structures of synthetic lattices, and experimentally demonstrate it in a modulated ring resonator. We also realize long-range couplings, photonic gauge potentials and nonreciprocal bands.

Executive Ballroom 210C

CLEO: QELS-Fundamental Science

13:30–15:30
FM3C • Functional Nanophotonics Using Metasurfaces
Presider: Wei Ting Chen Harvard Univ., USA

FM3C.1 • 13:30
A strongly correlated material for tunable metasurfaces, Weijian Li[1,2], Gururaj Naik[2]; *[1]Applied Physics Graduate Program, Smalley-Curl Inst., Rice Univ., USA; [2]Electrical & Computer Engineering, Rice Univ., USA.* We demonstrate intensity dependent optical response in the visible for a strongly correlated material, 1T-TaS_2. Using this tunable material, we show the intensity-dependent diffraction of a meta-grating device useful for imaging, display and sensing technologies.

FM3C.2 • 13:45
Polariton Meta-Optics with Phase-Change Materials, Michele Tamagnone[1], Kundan Chaudhary[1], Xinghui Yin[1], Christina Spagele[1], Jiahan Li[2], Stefano Oscurato[1], Noah Rubin[1], Luis Jauregui[1], Philip Kim[1], James Edgar[2], Antonio Ambrosio[1], Federico Capasso[1]; *[1]Harvard Univerity, USA; [2]Kansas State Univ., USA.* We created polaritonic metalenses in heterostructures formed by hBN and GeSbTe and characterized them with SNOM. The metalenses are created switching the phase of GeSbTe below hBN from amorphous to crystalline, focusing hBN phonon polaritons.

FM3C.3 • 14:00
All-dielectric Deep Ultraviolet Metasurfaces, Cheng Zhang[1], Shawn Divitt[1], Qingbin Fan[2], Wenqi Zhu[1], Amit K. Agrawal[1], Ting Xu[2], Henri Lezec[1]; *[1]NIST, USA; [2]College of Engineering and Applied Science, Nanjing Univ., China.* We demonstrate low-loss all-dielectric metasurfaces operating down to a record-short deep-ultraviolet wavelength of 266 nm, with an efficiency of 60%.

Executive Ballroom 210D

13:30–15:30
FM3D • Ultrafast Coherent Spectroscopy
Presider: Keshav Dani Okinawa Institute of Science and Technology, Japan

FM3D.1 • 13:30
Revealing the Orientation Dependence of Coherent Coupling in Silicon-Vacancy Centers in Diamond, Matthew W. Day[1], Kelsey Bates[1], Christopher L. Smallwood[3,2], Ronald Ulbricht[4,2], Travis Autry[5,2], Rachel C. Owen[1], Geoffrey M. Diederich[6], Tim Schröeder[7], Edward S. Bielejec[8], Mark Siemens[6], Steven T. Cundiff[1,2]; *[1]Physics, Univ. of Michigan, USA; [2]JILA, USA; [3]Physics and Astronomy, San Jose State Univ., USA; [4]Physics and Astronomy, Nanyang Technological Univ., Singapore; [5]NIST, USA; [6]Physics and Astronomy, Univ. of Denver, USA; [7]Physics, Humboldt Univ. of Berlin, Germany; [8]Sandia National Labs, USA.* We investigate the orientation dependence of coherent coupling in the zero phonon line of an ensemble of SiV^- centers in diamond. The results indicate that crystal orientation and polarization could be tools for coherent optical control.

FM3D.2 • 13:45
Heterodimensionally confined carriers in III-V semiconductor nanostructures in multidimensional spectroscopy, Mirco Kolarczik[1], Aris Koulas-Simos[1], Bastian Herzog[1], Benjamin Lingnau[1], Sophia Helmrich[1], Kathy Lüdge[1], Nina Owschimikow[1], Ulrike K. Woggon[1]; *[1]Technische Universitaet Berlin, Germany.* Heterodimensional excitonic states are observed in InAs self-assembled quantum dots (QDs). They couple the zero-dimensional QD states to the surrounding continuum, resulting in equal dephasing times for QD ground state and excited state.

FM3D.3 • 14:00
Two-dimensional THz Spectroscopy of Exchange Interactions in Rare-earth Doped Garnets, Shovon Pal[1], Christian Tzschaschel[1], Amadé Bortis[1], Takuya Satoh[2], Manfred Fiebig[1]; *[1]Dept. of Materials, ETH Zurich, Switzerland; [2]Dept. of Physics, Kyushu Univ., Japan.* We study the correlation dynamics of the complex exchange interaction between the rare-earth and the transition metal in a garnet using two-dimensional terahertz spectroscopy. The THz resonance resembles a convolution of the exchange mode with electron transfer between the Kramer's doublet.

Executive Ballroom 210E

Joint

13:30–15:30
JM3E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications III
Presider: To Be Announced

JM3E.1 • 13:30 Invited
Industrial Ultrafast Lasers - Systems, Processing Fundamentals, and Applications, Norman Hodgson[1], Michael Laha[1], Tony Lee[1], Sebastian Heming[1,2], Albrecht Steinkopff[1,3]; [1]*Coherent, Inc., USA;* [2]*Univ. Muenster, Germany;* [3]*Univ. Jena, Germany.* The architectures of industrial ultrafast lasers are being reviewed and their performance compared. Ablations rates as a function of pulse duration (0.4 – 19 ps), wavelength and pulse fluence are presented and the main industrial applications are discussed.

JM3E.2 • 14:00 Invited
High Power and High Energy Ultrafast Disk Lasers for Industrial Applications, Dirk H. Sutter[1], Thomas Dietz[1], Dominik Bauer[1], Raphael Scelle[1], Aleksander Budnicki[1], Alexander Killi[1], Michael Jenne[2], Jonas Kleiner[2], Daniel Flamm[2], Marc Sailer[1], Malte Kumkar[2]; [1]*R+D, TRUMPF Laser GmbH, Germany;* [2]*Research + Development, TRUMPF Laser- und Systemtechnik GmbH, Germany.* Pico- and femtosecond lasers with kilowatt average power levels that are also capable of providing multi-mJ pulse energies will be described. Well established 24/7 industrial ultrafast laser processes allow for an outlook on potential future applications.

Executive Ballroom 210F

CLEO: Science & Innovations

13:30–15:30
SM3F • Hot Topics in Quantum Sensing
Presider: Susan Schima; NIST, USA

SM3F.1 • 13:30 Invited
Quantum Sensing with Interacting Atoms, Morgan Mitchell[1,2]; [1]*ICFO - The Inst. of Photonic Sciences, Spain;* [2]*ICREA - Catalan Institution for Research and Advanced Studies, Spain.* Most quantum sensing literature describes non-interacting particles, or equivalently linear interferometry. Important high performance sensors, in contrast, employ interacting particles. I will discuss the prospects for quantum enhancement of such instruments.

SM3F.2 • 14:00 Invited
Tests of Quantum Mechanics and Gravity Using Atom Interferometry, Mark A. Kasevich[1]; [1]*Stanford Univ., USA.* Modern de Broglie wave interferometers separate atomic wavepackets by 0.5 m for times of 2 sec. This talk will discuss the science and technology implications of these results, and describe the techniques employed to realize these instruments.

Executive Ballroom 210G

13:30–15:30
SM3G • Data Center Lightwave Communications
Presider: Giovanni Milione; NEC Laboratories America Inc., USA

SM3G.1 • 13:30 Tutorial
Flexibly Scalable High Performance Architectures with Embedded Photonics, Keren Bergman[1]; [1]*Columbia Univ., USA.* High-performance systems are increasingly bottlenecked by the energy and communications costs of interconnecting numerous compute and memory resources. We will review the opportunities to alleviate these challenges with embedded photonics and deliver flexibly scalable architectures.

Keren Bergman is the Charles Batchelor Professor of Electrical Engineering at Columbia University where she also serves as the Faculty Director of the Columbia Nano Initiative. Prof. Bergman received the B.S. from Bucknell University in 1988, and the M.S. in 1991 and Ph.D. in 1994 from M.I.T. all in Electrical Engineering. At Columbia, Bergman leads the Lightwave Research Laboratory encompassing multiple cross-disciplinary programs at the intersection of computing and photonics. Bergman serves on the Leadership Council of the American Institute of Manufacturing (AIM) Photonics leading projects that support the institute's silicon photonics manufacturing capabilities and Datacom applications. She is a Fellow of the OSA and IEEE.

Executive Ballroom 210H

13:30–15:30
SM3H • Fundamentals of Ultrafast Light Matter Interaction
Presider: Tsing-Hua Her: Univ. of North Carolina at Charlotte, USA

SM3H.1 • 13:30
Multiplicity of Laser-Excited Electromagnetic Modes and their Roles in LIPSS Formation on Thin Metallic Films, Alexandr V. Dostovalov[2], Thibault Derrien[1], Viktor P. Korolkov[2], Sergey A. Babin[2], Nadezhda M. Bulgakova[1]; [1]*HiLASE, Inst. of Physics ASCR, Russia;* [2]*Inst. of Automation and Electrometry SB RAS, Russia.* Two types of laser-induced periodic surface structures produced by ultrashort laser pulses on Cr films of different thickness have been created and explained, based on a rigorous model of plasmon polaritons and dynamics of oxidation.

SM3H.2 • 13:45
Single-Shot Few-Cycle Pulse Laser-Induced Damage and Ablation of HfO_2/SiO_2-based Optical Thin Films, Noah Talisa[1], Michael Tripepi[1,2], Brandon Harris[1], Abdallah AlShafey[1], Aaron Davenport[3], Emmett Randel[3], Carmen S. Menoni[3], Enam Chowdhury[1]; [1]*Ohio State Univ., USA;* [2]*Materials and Manufacturing Directorate, Air Force Research Labs, USA;* [3]*Electrical and Computer Engineering Dept., Colorado State Univ., USA.* Few-cycle pulse laser damage and ablation of HfO_2/SiO_2-based single-, double-, and quad-layer thin films are studied using time-resolved surface microscopy. Ablation of multilayer samples happens as fast as for the single-layer, indicating a "blow-out" mechanism.

SM3H.3 • 14:00 Tutorial
Ultrafast Laser Nanostructuring; Smart Beams for Smart Processes, Razvan Stoian[1]; [1]*Laboratoire Hubert Curien, CNRS Universite Jean Monnet, France.* Nanoscale capability is key to a new generation of precise ultrafast laser material processing tools, relying on smart concepts using designer pulses. We review several mechanisms of laser nanostructuring, with strategies for precise 2D-3D manufacturing.

continued on page 81

Meeting Room 211 A/B

CLEO: Applications & Technology

13:30–15:30
AM3I • Biomedical Imaging
Presider: Ilko K. Ilev U.S. Food and Drug Administration; USA

AM3I.1 • 13:30
Implementation and Characterization of a Compact Multiphoton Endoscope with Large Field of View Working at 1700 nm, Farhad Akhoundi[1], Yukun Qin[1], Nasser Peyghambarian[1]; [1]*Univ. of Arizona, USA.* The implementation and characterization of a compact multi-photon endoscope is presented. A miniscule objective lens with a long working distance is used. We utilized a 1700 nm wavelength femtosecond laser to increase penetration depth.

AM3I.2 • 13:45
Reconstruction of Multiple-Scattering Complex Media by Iterative Optical Diffraction Tomography, Shengli Fan[1], Seth D. Smith-Dryden[1], Guifang Li[1], Bahaa Saleh[1]; [1]*CREOL, The College of Optics & Photonics, USA.* We demonstrated the reconstruction of complex media beyond the weakly-scattering regime using iterative diffraction tomography. The accuracy and efficiency of the iterative reconstruction are numerically demonstrated.

AM3I.3 • 14:00 Invited
Optoacoustic Imaging Beyond the Diffraction Limit, X Luis Dean-Ben[1], Daniel Razansky[1]; [1]*Univ. and ETH Zurich, Switzerland.* The talk focuses on novel super-resolution optoacoustic approaches enabling imaging beyond the diffraction limit, such as localization tomography of flowing particles, non-linear bleacing effects, dynamic speckle excitation and wavefront shaping.

Meeting Room 211 C/D

CLEO: Science & Innovations

13:30–15:30
SM3J • Silicon Photonics
Presider: Zhihong Huang; Hewlett Packard laboratories, USA

SM3J.1 • 13:30
Monolithically Integrated InP-on-Si Microdisk Lasers with Room-Temperature Operation, Svenja Mauthe[1], Philipp Staudinger[1], Noelia Vico Trivino[1], Marilyne Sousa[1], Thilo Stöferle[1], Heinz Schmid[1], Kirsten E. Moselund[1]; [1]*IBM Research Zurich, Switzerland.* We present the first monolithic integration of InP microdisk room-temperature lasers on silicon by template-assisted-selective-epitaxy and compare their performance with previously demonstrated GaAs microdisk lasers. InP allows for future integration of QWs for the NIR.

SM3J.2 • 13:45
Waveguide-Integrated Dielectric Laser Particle Accelerators Through the Inverse Design of Photonics, Neil Sapra[1], Kiyoul Yang[1], Dries Vercruysse[1,2], Logan Su[1], Jelena Vuckovic[1]; [1]*Ginzton Lab, Stanford Univ., USA;* [2]*Dept. of Physics, KU Leuven, Belgium.* We apply the inverse design methodology to waveguide-integrated dielectric laser particle accelerators. These accelerators are optimized to maximize the acceleration gradient. The designs have been fabricated on a silicon-on-insulator platform and experimentally characterized.

SM3J.3 • 14:00 Invited
New Concepts in Silicon Photonics: From Optical Communications to the Brain, Joyce K. Poon[1,2]; [1]*Univ. of Toronto, Canada;* [2]*Max Planck Inst. for Microstructure Physics, Germany.* I will present monolithically integrated multi-level silicon nitride-on-silicon photonic platforms that support 3D integrated photonic devices and circuits for telecommunications, and our recent efforts to extend this work to realize neurophotonic implants for brain activity mapping.

Meeting Room 212 A/B

CLEO: Applications & Technology

13:30–15:30
AM3K • A&T Topical Review on Flat Optics I
Presider: To Be Announced

AM3K.1 • 13:30 Invited
New Physics and Applications with Metasurfaces, Vladimir M. Shalaev[1]; [1]*Purdue Univ./Birck Nanotechnology, USA.* Via in-plane optical phase control, metasurfaces serve as an illustration platform for new physical phenomena including ultrafast beam steering, optical switching, synchrotron radiation, and new applications such as multiplexed color display and efficient thermo-photovoltaic generation.

AM3K.2 • 14:00
High NA Free-Space Focusing Using a Metasurface-Integrated Photonic Platform for Atom Trapping, Alexander Yulaev[1,2], Wenqi Zhu[1,2], Cheng Zhang[1,2], Daron Westly[2], Henri Lezec[2], Amit K. Agrawal[1,2], Vladimir Aksyuk[2]; [1]*IREAP, Univ. of Maryland, USA;* [2]*PML, National Inst. of Standards and Technology, USA.* We report a compact, general photonic-to-free-space coupling via integrating metasurfaces with planar photonics. Demonstrated collimated beam projection and high numerical aperture focusing at long distance may enable trapping and interrogating atoms in chip-scale systems.

Meeting Room 212 C/D

CLEO: Science & Innovations

13:30–15:30
SM3L • Fiber Amplifiers
Presider: Guoqing Chang; Institute of Physics, CAS, China

SM3L.1 • 13:30 Tutorial
Coherent Combination of Fiber Amplified Femtosecond Pulses, Jens Limpert[1]; [1]*Friedrich-Schiller-Universität Jena, Germany.* The presentation will review the basics, achievements and newest developments of coherent combination of amplified femtosecond pulses, a concept which has already out-performed single aperture femtosecond laser systems and which allows for a scaling to unprecedented performance levels.

Jens Limpert received his M.S in 1999 and Ph.D. in Physics from the Friedrich Schiller University of Jena in 2003. His research interests include high power fiber lasers in the pulsed and continuous-wave regime, in the near-infrared and visible spectral range. He is author or co-author of more than 350 peer-reviewed journal papers in the field of laser physics. His research activities have been awarded with the WLT-Award in 2006, an ERC starting grant in 2009 and an ERC consolidator grant in 2013. Jens Limpert is founder of the Active Fiber Systems GmbH a spin-off from the University Jena and the Fraunhofer-IOF Jena.

Marriott
Salon I & II

Joint

13:30–15:30
JM3M • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect I
Presider: To Be Announced

JM3M.1 • 13:30 Invited
Integrated Photonics for Neural Network Acceleration, Folkert Horst[1]; [1]*IBM Research - Zurich, Switzerland.* We will present our work on an analog integrated optical processor for the acceleration of Backpropagation Algorithm based training of Artificial Neural Networks.

JM3M.2 • 14:00 Invited
Generative Model for the Inverse Design of Photonic Nanostructures, Wenshan Cai[1]; [1]*Georgia Inst. of Technology, USA.* We present a deep-learning enabled generative framework for the inverse design of photonic structures. When fed with customer-defined optical spectra, the network generates candidate patterns that match the on-demand spectra with high fidelity.

Marriott
Salon III

CLEO: Science & Innovations

13:30–15:30
SM3N • Novel Optoelectronic Devices
Presider: Åsa Haglund, Chalmers University of Technology, Sweden

SM3N.1 • 13:30
Self-suspended Single-mode Microdisk Lasers, Wanwoo Noh[1], Matthieu Dupre[1], Abdoualye Ndao[1], Ashok Kodigala[1], Boubacar Kanté[1]; [1]*Univ. of California San Diego, USA.* We report subwavelength microdisk resonators suspended in air by connecting bridges. By optimizing the bridge configuration, we numerically and experimentally demonstrate mode selection and single mode microdisk lasers operating at near-infrared wavelength.

SM3N.2 • 13:45
Bending-induced tunable threshold in random laser, Ya-Ju Lee[1], Ting-Wei Yeh[1], Zu-Po Yang[2], Yung-Chi Yao[1], Chen-Yu Chang[1], Meng-Tsan Tsai[3], Jinn-Kong Sheu[4]; [1]*National Taiwan Normal Univ., Taiwan;* [2]*Inst. of Photonic System, National Chiao-Tung Univ., Taiwan;* [3]*Dept. of Electrical Engineering, Chang Gung Univ., Taiwan;* [4]*Dept. of Photonics, National Cheng Kung Univ., Taiwan.* We investigate the transport mean free path of emitted photons within disordered scatterers istunable by bending substrates, thereby creating a light source able to be operated above and below threshold for desirable spectral emissions.

SM3N.3 • 14:00
Autaptic Circuits of Integrated Laser Neurons, Hsuan-Tung Peng[1], Thomas Ferreira de Lima[1], Mitchell A. Nahmias[1], Alexander N. Tait[3], Bhavin J. Shastri[2], Paul R. Prucnal[1]; [1]*Princeton Univ., USA;* [2]*Physics, Queen's Univ., Canada;* [3]*National Inst. of Standard Technology, USA.* The presence of autapses in neural networks enables complex temporal dynamics and information storage. We experimentally demonstrated feedback dynamics in an integrated laser neuron, which provides a proof-of-principle demonstration of cascadability and stable recurrent memory.

Marriott
Salon IV

13:30–15:15
SM3O • Guided Wave Nonlinear Devices
Presider: Shu-Wei Huang; University of Colorado, Boulder, USA

SM3O.1 • 13:30 Invited
Integrated Lithium Niobate Photonics and Applications, Marko Loncar[1,2]; [1]*Harvard Univ., USA;* [2]*HyperLight Corporation, USA.* I will present ultra-low loss thin film lithium niobate photonics platform that enables realization of high-Q optical cavities, efficient electro-optic modulators, and broad frequency combs. Applications in telecommunications, microwave-photonics, and quantum photonics will be discussed.

SM3O.2 • 14:00
Ultrabroadband Nonlinear Optics in Dispersion Engineered Periodically Poled Lithium Niobate Waveguides, Marc Jankowski[1], Carsten Langrock[1], Boris Desiatov[2], Alireza Marandi[3], Cheng Wang[2], Mian Zhang[2], Christopher Phillips[4], Marko Loncar[2], Martin Fejer[1]; [1]*Stanford Univ., USA;* [2]*John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA;* [3]*Caltech, USA;* [4]*Dept. of Physics, Inst. of Quantum Electronics, ETH Zurich, Switzerland.* We experimentally demonstrate the first generation of dispersion-engineered periodically poled lithium niobate (PPLN) waveguides. These waveguides achieve ultra-broadband second-harmonic generation (SHG) and multi-octave supercontinuum generation (SCG) with record-low pulse energies.

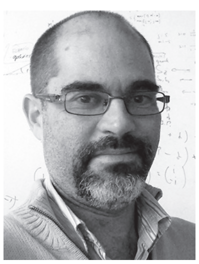
Executive Ballroom 210A

CLEO: QELS-Fundamental Science

FM3A • Quantum Nanophotonics I: Plasmonics & Quantum Dots—Continued

FM3A.4 • 14:15
Spin-Selective AC Stark Shifts in a Charged Quantum Dot, Tristan A. Wilkinson[1], Dillion Cottrill[1], Josh Cramlet[1], Cole Maurer[1], Collin Flood[1], Allan S. Bracker[2], Dan Gammon[2], Edward B. Flagg[1]; [1]*West Virginia Univ., USA;* [2]*Naval Research Lab, USA.* We demonstrate a spin-selective modification to the energy structure of a charged quantum dot using the AC Stark effect. This mechanism offers a potentially rapid, reversible, and coherent control of the energy structure.

FM3A.5 • 14:30 Tutorial
Quantum Nanophotonics: Manipulating Photons at the Subwavelength Regime, Gabriel Molina-Terriza[12]; [1]*IKERBASQUE, Basque Foundation for Science, Spain;* [2]*Materials Physics Center (CSIC-UPV/EHU), Spain.* I will give an overview of quantum nanophotonics. I will focus on the control of the quantum correlations of light and its applications to interacting with nanoparticles: single photon, entangled and squeezed states.



I am an Ikerbasque Research Professor leading the Quantum Nanophotonics Laboratory in the Materials Physics Center (Spain). I obtained my Ph.D. in 2002. Since then, my research is focused on the spatial properties of light, such as the angular momentum, and applications to Quantum Information, Nanophotonics and Optical levitation.

Executive Ballroom 210B

Joint

JM3B • Symposium on Nonreciprocal Photonics II—Continued

JM3B.3 • 14:15
Spontaneous Symmetry Breaking Based Near-Field Sensing with a Microresonator, Andreas Svela[1,2], Jonathan M. Silver[1,4], Leonardo Del Bino[1,3], George Ghalanos[1,2], Niall Moroney[1,2], Michael T. M. Woodley[1,3], Shuangyou Zhang[1], Michael Vanner[2], Pascal DelHaye[1]; [1]*National Physical Lab, UK;* [2]*Blackett Lab, Imperial College London, UK;* [3]*Heriot-Watt Univ., UK;* [4]*City, Univ. of London, UK.* The nonlinear Kerr effect causes spontaneous symmetry breaking in bi-directionally pumped whispering gallery mode resonators, providing a system highly sensitive to external perturbations. We demonstrate symmetry-breaking-enhanced near-field sensing within a microresonator's evanescent field.

JM3B.4 • 14:30 Invited
Magnetooptical Garnets for Nonreciprocal Integrated Photonics, Caroline Ross[1], Takian Fakhrul[1], Yan Zhang[2], Qungyang Du[1], Lukas Beran[3], Stana Tazlaru[3], Martin Veis[3], Lei Bi[2], Juejun Hu[1]; [1]*MIT, USA;* [2]*Univ. of Electronic Science and Technology of China, China;* [3]*Charles Univ., Czechia.* The magnetooptical figure of merit of polycrystalline Bi, Ce- and Tb-substituted yttrium iron garnet films on silicon and the performance of integrated TM and TE isolators based on both ring resonators and Mach-Zehnder interferometers with garnet cladding are described.

Executive Ballroom 210C

CLEO: QELS-Fundamental Science

FM3C • Functional Nanophotonics Using Metasurfaces—Continued

FM3C.4 • 14:30
High-Q resonance train in a plasmonic metasurface, Md Saad-Bin-Alam[1], Orad Reshef[5], Mikko J. Huttunen[2], Graham Carlow[3], Brian Sullivan[3], Jean-Michel Menard[5], Ksenia Dolgaleva[1,5], Robert W. Boyd[1,4]; [1]*School of Electrical Engineering and Computer Science, Univ. of Ottawa, Canada;* [2]*Lab of Photonics, Tampere Univ., Finland;* [3]*Iridian Spectral Technologies Inc., Canada;* [4]*The Inst. of Optics and Dept. of Physics and Astronomy, Univ. of Rochester, USA;* [5]*Dept. of Physics, Univ. of Ottawa, Canada.* We experimentally demonstrate a plasmonic surface that supports a series of high-quality-factor (Q~100) surface lattice resonances. These resonances are enabled by tuning the thickness of the top-cladding layer to confine higher order diffraction-orders.

FM3C.5 • 14:45
Nanoplasmonic Metamaterial Devices as Electrically Switchable Perfect Mirrors and Perfect Absorbers, Debabrata Sikdar[1,2], Ye Ma[1], Anthony Kucernak[1], Joshua Edel[1], Alexei Kornyshev[1]; [1]*Imperial College London, UK;* [2]*EEE, Indian Inst. of Technology guwahati, India.* We introduce nanoplasmonic metamaterial devices — electrically-switchable between perfect- mirror/absorber states — based on voltage-controlled assembly/disassembly of gold nanoparticles on silver films. These are investigated using effective-medium-theory, verified with simulations and experiments.

Executive Ballroom 210D

FM3D • Ultrafast Coherent Spectroscopy—Continued

FM3D.4 • 14:15
Ultrafast Analysis and Control of Sub-Nanosecond Intraband Coherence in Single CdSe/ZnSe Quantum Dots, Christian Traum[1], Philipp Henzler[1], David Nabben[1], Matthias Holtkemper[2], Doris E. Reiter[2], Tilmann Kuhn[2], Denis Seletskiy[1,3], Alfred Leitenstorfer[1]; [1]*Dept. of Physics and Center for Applied Photoncis, Univ. of Konstanz, Germany;* [2]*Solid State Theory, Univ. of Münster, Germany;* [3]*Dept. of Engineering Physics, Polytechnique Montréal, Canada.* Excited trion triplet states are studied with two-color femtosecond resolution monitoring induced absorption into charged biexciton levels. Quantum beats of single-electron wave packets with sub-nanosecond dephasing are found and controlled by pump and probe polarizations.

FM3D.5 • 14:30
Polarization-Selective Excitation of Triplet State Coherences in CsPbI3 Perovskite Nanocrystals, Albert Liu[1], Diogo B. Almeida[2], Luiz Bonato[3], Gabriel Nagamine[2], Luiz Zagonel[2], Ana F. Nogueira[3], Lazaro A. Padilha[2], Steven T. Cundiff[1]; [1]*Univ. of Michigan, USA;* [2]*Instituto de Fisica, Universidade Estadual de Campinas, Brazil;* [3]*Instituto de Quimica, Universidade Estadual de Campinas, Brazil.* We study CsPbI3 perovskite nanocrystals using polarization-resolved 2D coherent spectroscopy at cryogenic temperatures. Coherences involving triplet exciton states are revealed and characterized, including inter-triplet coherences with dephasing times on the picosecond timescale.

FM3D.6 • 14:45
Ultrafast Carrier Dynamics in Graphite Studied by Visible/Multi-THz 2D Spectroscopy, Jonas Allerbeck[1], Laurens Spitzner[1], Takayuki Kurihara[1], Alfred Leitenstorfer[1], Daniele Brida[2,1]; [1]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany;* [2]*Physics and Materials Science Research Unit, Université du Luxembourg, Luxembourg.* Two-dimensional spectroscopy employing an asymmetric scheme with visible excitation and multi-THz readout is applied to study ultrafast carrier dynamics in graphite, enabling phase sensitive investigation of correlations between high- and low-energy excitations.

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H

Joint

JM3E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications III—Continued

JM3E.3 • 14:30 Invited
Industrial kilowatt femtosecond lasers: potentialities and challenges, Clemens Hoenninger[1], Julien Pouysegur[1], Benoit Tropheme[1], Florent Basin[1], Martin Delaigue[1], Jorge Sanabria[1], Guillaume Bonamis[1], Konstantin M. mishchik[1], Eric Audouard[1], Eric Mottay[1]; [1]*Amplitude, France.* High throughput micromachining fuels the trend towards kilowatt femtosecond lasers. We present and discuss the potentialities offered as well as challenges to address, including advanced temporal, spectral, and spatial beam shaping.

CLEO: Science & Innovations

SM3F • Hot Topics in Quantum Sensing—Continued

SM3F.3 • 14:30
Rydberg-Atoms Based Radio-Frequency Electric Field and Power Sensors for Quantum SI-Traceable Measurements, Christopher L. Holloway[1], Matthew Simons[1], Joshua Gordon[1]; [1]*NIST, USA.* We discuss a fundamentally new method for electric (E) field strength (V/m) and power (W) metrology based on the interaction of radio-frequency (RF) E-fields with Rydberg atoms (alkali atomic vapor excited optically to Rydberg states).

SM3F.4 • 14:45
Atomic cladded waveguide for chip scale stabilization and modulation of telecom wavelengths, Roy T. Zektzer[1], Eliran Talker[1], Yefim Barash[1], Noa Mazurski[1], Uriel Levy[1]; [1]*The Hebrew Univ. of Jerusalem, Israel.* We experimentally demonstrate a chip-scale integration of photonic waveguides and alkali vapor for frequency reference and modulation. A telecom signal was stabilized to rubidium ladder transition and was modulated by a 780nm pump laser.

SM3G • Data Center Lightwave Communications—Continued

SM3G.2 • 14:30
FlexLION: A Reconfigurable All-to-All Optical Interconnect Fabric with Bandwidth Steering, Roberto Proietti[1], Gengchen Liu[1], Xian Xiao[1], Sebastian Werner[1], Pouya Fotouhi[1], S.J.Ben Yoo[1]; [1]*Univ. of California Davis, USA.* We demonstrate an all-to-all interconnect fabric with bandwidth steering by wavelength routing, wavelength add/drop filtering and spatial switching. We report a proof-of-concept experiment and demonstrate scalability up to 32 ports with aggregated bandwidth of 51.2Tb/s under worst-case crosstalk.

SM3G.3 • 14:45
Demonstration of Kramers-Kronig Detection of Four 20-Gbaud 16-QAM Channels after 50-km Transmission Using Kerr Combs to Perform Shared Phase Estimation, Kaiheng Zou[1], Peicheng Liao[1], Changjing Bao[1], Yinwen Cao[1], Arne Kordts[2], Ahmed Almaiman[1,3], Maxim Karpov[2], Martin Pfeiffer[2], Fatemeh Alishahi[1], Ahmad Fallahpour[1], Moshe Tur[4], Tobias J. Kippenberg[2], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [3]*King Saud Univ., Saudi Arabia;* [4]*Tel Aviv Univ., Israel.* We experimentally demonstrate KK detection of four 20-Gbaud 16-QAM channels after 50-km transmission using two soliton Kerr combs at transmitter and receiver. The frequency comb coherence enables a shared phase noise estimation among multiple channels.

SM3H • Fundamentals of Ultrafast Light Matter Interaction—Continued

Razvan Stoian (MSc Bucharest University, PhD Free University Berlin) is research director at the Centre Nationale de la Recherche Scientifique France. He is leading the Laser-Matter Interaction group at Laboratoire Hubert Curien, St. Etienne. His research interests include laser matter interaction and ultrafast laser micro-nano fabrication for functional surfaces and photonics.

Meeting Room 211 A/B

CLEO: Applications & Technology

AM3I • Biomedical Imaging—Continued

AM3I.4 • 14:30 Invited
Second Harmonic Generation Probes of Human Ovarian Cancer, Paul J. Campagnola[1], Eric Rentchler[1], Manish Patankar[1], Kirby Campbell[1]; [1]*Univ. of Wisconsin-Madison, USA.* We use Second Harmonic Generation microscopy to characterize extracellular matrix changes in human ovarian cancers. Texture analysis and polarization resolved techniques differentiate a spectrum of tumors based on alterations in fibrillar organization and supramolecular structure.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM3J • Silicon Photonics—Continued

SM3J.4 • 14:30
Efficient Telecom-to-Visible Spectral Translation Using Silicon Nanophotonics, Xiyuan Lu[1,2], Gregory Moille[1,2], Qing Li[1,3], Daron Westly[1], Ashotosh Rao[1,2], Su-Peng Yu[1], Travis C. Briles[1], Scott B. Papp[1], Kartik Srinivasan[1]; [1]*NIST, USA;* [2]*Univ. of Maryland College Park, USA;* [3]*Carnegie Mellon Univ., USA.* We demonstrate efficient spectral translation of a continuous-wave optical signal across 250 THz using cavity-enhanced four-wave mixing on a silicon nanophotonics chip, with up to 12.8 % photon number efficiency achieved for sub-mW pump power.

SM3J.5 • 14:45
Experimental demonstration of rapid adiabatic couplers, Josep Fargas Cabanillas[1], Hayk Harutyunyan[1], Anatol Khilo[1], Milos Popovic[1]; [1]*ECE, Boston Univ., USA.* We experimentally demonstrate rapid adiabatic coupling (RAC), a novel design concept that harnesses the benefits and avoids the disadvantages of adiabatic photonic structures. The 31um long 2x2 coupler shows 3±0.3dB splitting over 130nm bandwidth.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM3K • A&T Topical Review on Flat Optics I—Continued

AM3K.3 • 14:15
Reconfigurable mid-infrared optical elements using phase change materials, Xinghui Yin[1], Christina Spagele[1], Michele Tamagnone[1], Kundan Chaudhary[1], Stefano Oscurato[1], Jiahan Li[2], Ruoping Li[1], Noah Rubin[1], Luis Jauregui[1], Philip Kim[1], James Edgar[2], Antonio Ambrosio[1], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*Chemical Engineering, Kansas State Univ., USA.* Reconfigurable optical elements using the phase change material $Ge_3Sb_2Te_6$ are demonstrated for freely propagating light as well as phonon polaritons in hexagonal boron nitride.

AM3K.4 • 14:30 Invited
Nonlinear and topological meta-optics and metasurfaces, Yuri S. Kivshar[1,2]; [1]*Australian National Univ., Australia;* [2]*ITMO Univ., Russia.* This talk will summarize the major concepts of all-dielectric Mie-resonant meta-optics, including nanophotonic structures and metasurfaces. It will present also recent advances from my groups in Canberra and St. Petersburg on dielectric nanophotonics as well as nonlinear and topological metasurfaces.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM3L • Fiber Amplifiers—Continued

SM3L.2 • 14:30
100-W Average-Power Femtosecond Fiber Laser System with Variable Parameters for Rapid Optimization of Laser Processing, Dai Yoshitomi[1], Hideyuki Takada[1], Kenji Torizuka[1], Yohei Kobayashi[2]; [1]*Natl Inst of Adv Industrial Sci & Tech, Japan;* [2]*Inst. Solid State Physics, Univ. Tokyo, Japan.* We developed a femtosecond fiber-laser system delivering an average power up to 100 W with wide variability of parameters: pulse duration, pulse energy, number of pulses, and repetition rate for rapid optimization of laser processing.

SM3L.3 • 14:45
Pre-Chirp Managed Amplification of Circularly Polarized Pulses Using chirped Mirrors for Pulse Compression, Hangdong Huang[2], Yao Zhang[2], Hao Teng[1], Shaobo Fang[1], Junli Wang[2], Jiangfeng Zhu[2], Guoqing Chang[1], Zhiyi Wei[1]; [1]*Chinese Academy of Sciences, China;* [2]*Xi dian Univ., China.* We demonstrate an Yb-fiber based pre-chirp managed amplification system that amplifies circularly polarized pulses. Using chirped mirrors as the highly efficient (98%) compressor, the system emits 50-MHz, 42-fs pulses with 83-W average power.

Marriott
Salon I & II

Marriott
Salon III

Marriott
Salon IV

Joint

JM3M • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect I—Continued

JM3M.3 • 14:30 Invited

Multiwavelength Neuromorphic Photonics, Paul R. Prucnal[1], Alexander N. Tait[1], Mitchell A. Nahmias[1], Thomas Ferreira de Lima[1], Hsuan-Tung Peng[1], Bhavin J. Shastri[2]; [1]*Princeton Univ., USA;* [2]*Dept. of Physics, Engineering Physics & Astronomy, Queen's Univ., Canada.* Neuromorphic photonics promises orders of magnitude improvements in both speed and energy efficiency over digital electronics. We will give an overview of neuromorphic photonic systems and their application to optimization and machine learning problems.

CLEO: Science & Innovations

SM3N • Novel Optoelectronic Devices—Continued

SM3N.4 • 14:15

Blue Superluminescent Diodes with GHz Bandwidth Exciting Perovskite Nanocrystals for High CRI White Lighting and High-Speed VLC, Abdullah Al-atawi[1,2], Jorge A. Holguin-Lerma[1], Chun Hong Kang[1], Chao Shen[1], Ibrahim Dursun[1], Lutfan Sinatra[3], Abdulrahman albadri[2], Ahmad Alyamani[2], Tien Khee Ng[1], Osman Bakr[1], Boon S. Ooi[1]; [1]*King Abdullah Univ of Sci & Technology, Saudi Arabia;* [2]*National Center for Nanotechnology, King Abdulaziz City for Science and Technology, Saudi Arabia;* [3]*Quantum Solutions LLC, Saudi Arabia.* A 442-nm GaN-based superluminescent diode (SLD) is demonstrated with a GHz modulation bandwidth and a linewidth of 7 nm. When use for exciting $CsPbBr_3$-perovskite nanocrystal-phosphor, warm-white light with a high CRI of 91 was achieved.

SM3N.5 • 14:30

Wideband Self-injection-locked Green Tunable Laser Diode, Md. Hosne Mobarok Shamim[1], Tien Khee Ng[2], Boon S. Ooi[2], Mohammed Zahed Mustafa Khan[1]; [1]*King Fahd Univ. of Petroleum & Mine, Saudi Arabia;* [2]*Computer, Electrical and Mathematical Sciences and Engineering (CEMSE) division, King Abdullah Univ. of Science & Technology (KAUST), Saudi Arabia.* A wideband tunability of 6.53 nm with appreciable SMSR (>10 dB) and linewidth (~0.1 nm) is demonstrated from a simple and low-cost tunable self-injection locked InGaN/GaN green laser based external-cavity system, for the first time.

SM3N.6 • 14:45

12.5-GHz InP Quantum Dot Monolithically Mode-Locked Lasers Emitting at 740 nm, Zhibo Li[1], Samuel Shutts[1], Craig Allford[1], Andrey Krysa[2], Peter Smowton[1]; [1]*School of Physics and Astronomy, Cardiff Univ., UK;* [2]*Univ. of Sheffield, UK.* Monolithic InP/GaInP quantum dot passively mode-locked lasers, designed using gain and absorption measurements, are realised for the first time, emitting at 740 nm with 12.5 GHz repetition frequency.

SM3O • Guided Wave Nonlinear Devices—Continued

SM3O.3 • 14:15

Quadratic Cavity Soliton Optical Frequency Combs, Tobias Hansson[1,2], P. Parra-Rivas[3,5], F. Leo[3], M. Bernard[2], L. Gelens[5], Stefan Wabnitz[4,2]; [1]*Linkoping Univ., Sweden;* [2]*Univ. of Brescia, Italy;* [3]*Free Univ. of Brussels, Belgium;* [4]*Sapienza Università di Roma, Italy;* [5]*Univ. of Leuven, Belgium.* We theoretically demonstrate, in the absence of a temporal walk-off, the existence of both bright and dark coherent cavity soliton optical frequency combs in a dispersive second-harmonic generation cavity system.

SM3O.4 • 14:30

Frequency comb generation in a continuous–wave pumped second–order nonlinear waveguide resonator, Zeina Abdallah[1], Michael Stefszky[2], Ville Ulvila[3,4], Christine Silberhorn[2], Markku M. Vainio[3,1]; [1]*Lab of Photonics, Tampere Univ. of Technology, Finland;* [2]*Integrated Quantum Optics, Applied Physics, Paderborn Univ., Germany;* [3]*Molecular Science, Dept. of Chemistry, Univ. of Helsinki, Finland;* [4]*VTT Technical Research Centre of Finland Ltd, Finland.* Optical frequency comb generation has been experimentally studied using an integrated system based on a lithium niobate waveguide resonator featuring a strong quadratic nonlinearity. Our theoretical model shows good agreement with the experimental results.

SM3O.5 • 14:45

Wafer-scale GaAs-on-insulator Waveguide Platform for Diverse Nonlinear Processes, Eric J. Stanton[1], Jeff Chiles[1], Nima Nader[1], Sae Woo Nam[1], Richard P. Mirin[1]; [1]*Applied Physics Division, National Inst. of Standards and Technology, USA.* We detail a 76 mm wafer-bonding process for high-yield GaAs-on-insulator waveguides. Second-harmonic generation waveguides are designed with 120 $W^{-1}cm^{-2}$ conversion efficiency, and a microresonator is demonstrated with a 180,000 quality factor.

Executive Ballroom 210A

CLEO: QELS-Fundamental Science

FM3A • Quantum Nanophotonics I: Plasmonics & Quantum Dots—Continued

Executive Ballroom 210B

Joint

JM3B • Symposium on Nonreciprocal Photonics II—Continued

JM3B.5 • 15:00
Strong-Magneto Optical Response Enabled by Quantum Two-Level Systems, Lei Ying[1], Ming Zhou[1], Zongfu Yu[1]; [1]*Univ. of Wisconsin-Madison, USA.* By tailoring the resonant interplay between quantum two-level systems and classical metallic nanostructures, we theoretically propose a composite material system that exhibits an intrinsic magneto-optical response orders of magnitude stronger than most magneto-optical materials used today.

JM3B.6 • 15:15
Observation of the nonreciprocal adiabatic geometric phase in nonlinear optics, Aviv Karnieli[1], Sivan Trajtenberg-Mills[1], Giuseppe Di Dominico[1], Ady Arie[1]; [1]*TAU, Israel.* We demonstrate both theoretically and experimentally, a robust scheme that generates an adiabatic geometric phase via frequency conversion. By tailoring nonlinear photonic crystals we create nonlinear geometric phase plates which also exhibit optical nonreciprocity.

Executive Ballroom 210C

CLEO: QELS-Fundamental Science

FM3C • Functional Nanophotonics Using Metasurfaces—Continued

FM3C.6 • 15:00
Deep subwavelength plasmonic metamaterial absorbers for infrared detection, Junyu Li[1], Haoran Zhou[1], Fei Yi[1,2]; [1]*Huazhong Univ. of Science and Technology, China;* [2]*Shenzhen Huazhong Univ. of Science and Technology Research Inst., China.* Here we report a metal-insulator-metal based infrared plasmonic metamaterial absorber consisting of deep subwavelength meander line nanoantennas. High absorption from 11 μm to 14 μm is experimentally demonstrated with a pixel pitch of 1.47 μm.

FM3C.7 • 15:15
Reconfigurable Dispersion Compensation and Pulse Shaping by Optical Metasurfaces, Wenqi Zhu[2,1], Shawn Divitt[2,1], Cheng Zhang[2,1], Lu Chen[2], Henri Lezec[2], Amit K. Agrawal[2,1]; [1]*Univ. of Maryland College Park, USA;* [2]*National Inst. of Standards and Technology, USA.* Metasurfaces offer the ability to control optical dispersion with extreme resolution. Here, we demonstrate reconfigurable dispersion control of ultrafast laser pulses through a set of silicon metasurfaces forming a Taylor series expansion in optical phase.

Executive Ballroom 210D

FM3D • Ultrafast Coherent Spectroscopy—Continued

FM3D.7 • 15:00
Terahertz Near-Field Nano-Spectroscopy of Antiferromagnetic Resonance, Richard H. Kim[1], Yilong Luan[1], Zhe Fei[1], Jigang Wang[1]; [1]*Iowa State Univ., USA.* We developed a terahertz scanning near-field nanoscope to visualize the spectral-temporal responses of antiferromagnetic modes in $Sm_{0.4}Er_{0.6}FeO_3$. Our results demonstrate the first detection of collective spin precession at the femtosecond and nanometer scales.

FM3D.8 • 15:15
Strong Coupling of Light with Collective Terahertz Vibrations in Organic Materials, Ran Damari[1,2], Omri Weinberg[1], Natalia Demina[1], Katherine Akulov[1,2], Daniel Krotkov[1,2], Sharly Fleischer[1,2], Tal Schwartz[1,2]; [1]*Physical Chemistry Dept., Tel-Aviv Univ., Israel;* [2]*Tel Aviv Center for Light-Matter Interaction, Tel Aviv Univ., Israel.* We demonstrate for the first time strong coupling between a terahertz cavity and collective, intermolecular vibrations in organic crystals. Beyond observing the Rabi splitting, we directly measure the vacuum Rabi oscillations using time-domain THz spectroscopy.

14:30–16:00 Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, *Guadalupe Room, San Jose Marriott*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

16:00–17:30 Professional Development for Busy Professionals, *Salon VI, San Jose Marriott*

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H

Joint

JM3E • Symposium on High Average Power Ultrafast Lasers: Trends, Challenges & Applications III—Continued

JM3E.4 • 15:00
1 MHz Ultrafast High Order Cascaded VUV Generation in Negative Curvature Hollow Fibers, Jessica Ramirez[1], David Couch[2], Daniel Hickstein[1], Mathew Kirchner[1], Henry Kapteyn[1,2], Margaret M. Murnane[2,1], Sterling J. Backus[1,2]; [1]*KMLabs, USA;* [2]*JILA, Univ. of Colorado, USA.* We demonstrate cascaded harmonic generation to 9[th] harmonic (115nm) of 1040nm by combining the fundamental and SHG in a negative curvature hollow fiber filled with Xenon gas.

CLEO: Science & Innovations

SM3F • Hot Topics in Quantum Sensing—Continued

SM3F.5 • 15:00 Invited
Point Source Atom Interferometry for Inertial Navigation and Precision Measurements, Yun-Jhih Chen[1,2], Azure Hansen[1], John Kitching[1], Elizabeth A. Donley[1]; [1]*National Inst. of Standards and Technology, USA;* [2]*Univ. of Colorado, USA.* We evaluate the technique of point source atom interferometry as a relatively simple approach for building an atom interferometer gyroscope. A sensitivity evaluation for simultaneous measurements of acceleration, rotation, and rotation angle will be presented.

SM3G • Data Center Lightwave Communications—Continued

SM3G.4 • 15:00
8-ary Stokes-Vector Signal Generation and Transmission Employing a Simplified Transmitter, Samir Ghosh[2], Shota Ishimura[2,1], Takahiro Suganuma[2], Takuo Tanemura[2], Yoshiaki Nakano[2]; [1]*KDDI Research, Inc., Japan;* [2]*School of Engineering, The Univ. of Tokyo, Japan.* We experimentally demonstrate a simple straight-line configuration of Stokes vector modulator with two cascaded phase modulators. Three-dimensional 8-ary Stokesvector-modulated signal is generated at 30 Gb/s and transmitted over a 50-km dispersioncompensated single-mode fiber.

SM3G.5 • 15:15
Iterative Block Decision Feedback Equalization for IM/DD-OCDM System to Mitigate CD-Induced Fading, Xing Ouyang[1], Giuseppe Talli[1], Paul Townsend[1]; [1]*Photonics Center, Tyndall National Inst., Ireland.* We propose an IM/DD-OCDM system with IB-DFE algorithm to mitigate chromatic-dispersion-induced fading and the results confirm that the BER performance can be improved by up to three orders of magnitude by compensating the fading effect.

SM3H • Fundamentals of Ultrafast Light Matter Interaction—Continued

SM3H.4 • 15:00
Femtosecond-laser ablation of monolayer molybdenum disulfide (MoS_2) on sapphire, Joel M. Solomon[1], Hsin-Yu Yao[2], Li-Syuan Lu[3], Wen-Hao Chang[3], Tsing-Hua Her[1]; [1]*Dept. of Physics and Optical Science, The Univ. of North Carolina at Charlotte, USA;* [2]*Dept. of Physics, National Tsing Hua Univ., Taiwan;* [3]*Dept. of Electrophysics, National Chiao Tung Univ., Taiwan.* Single-shot femtosecond laser ablation of monolayer molybdenum disulfide is demonstrated. An ablation threshold was found 0.9 nJ/μm^2, which is too low for two-photon photoionization alone. We show that surface defects and avalanche ionization are important.

SM3H.5 • 15:15
Femtosecond Laser Ablation of Monolayer Graphene with Analysis of the Structural Deformations, Andres Vasquez[1], Mohammad Alaghemandi[1], Junjie Zeng[1], Panagis Samolis[1], Adam Sapp[1], Sahar Sharifzadeh[1], Michelle Y. Sander[1]; [1]*Boston Univ., USA.* Experimental femtosecond laser ablation of graphene at a high repetition rate of 80 MHz with moderate pulse energies up 27.5 nJ is analyzed and structural deformations studied by reactive molecular dynamics simulations.

14:30–16:00 Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, *Guadalupe Room, San Jose Marriott*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

16:00–17:30 Professional Development for Busy Professionals, *Salon VI, San Jose Marriott*

Meeting Room 211 A/B

CLEO: Applications & Technology

AM3I • Biomedical Imaging—Continued

AM3I.5 • 15:00
Ultra-high-resolution single input state polarization-sensitive OCT with polarization distortion correction, Qiaozhou Xiong[1], Nanshuo Wang[1], Xinyu Liu[1], Si Chen[1], Shufen Chen[1], Haitao Liang[1], Linbo Liu[1,2]; [1]*School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore;* [2]*School of Chemical and Biomedical Engineering, Nanyang Technological Univ., Singapore.* In an ultra-high-resolution single input PS-OCT, we proposed a method for correcting polarization distortion caused by Quarter-wave plate (QWP) and spectrometers' roll-off mismatch. The method yielded better estimation of polarization properties especially in weakly birefringent samples.

AM3I.6 • 15:15
Fast Two-snapshot Structured Illumination for Wide-field Two-photon Microscopy with Enhanced Axial Resolution and Signal-to-noise Ratio, Yunlong Meng[1], Wei Lin[1], Jialong Chen[1], Chenglin Li[1], Shih-Chi Chen[1]; [1]*Dept. of Mechanical and Automation Engineering, The Chinese Univ. of Hong Kong, Hong Kong.* We have developed a fully adaptive fast two-snapshot structured illumination algorithm for fast data acquisition and image reconstruction, which can be used in wide-field two-photon microscopy with enhanced axial resolution (~1.25x) and signal-to-noise ratio.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM3J • Silicon Photonics—Continued

SM3J.6 • 15:00
Efficient Conversion to Very High Order Modes in Silicon Waveguides , Utsav D. Dave[1], Michal Lipson[1]; [1]*Electrical Engineering, Columbia Univ., USA.* We demonstrate robust mode conversion up to the 12th higher order mode in silicon waveguides by using an optimized adiabatic directional coupler and using subwavelength waveguides. The conversion efficiency is better than -1.5 dB over a 75 nm bandwidth and tolerating ±30 nm fabrication variations.

SM3J.7 • 15:15
SOI Optical Add-Drop Multiplexers Using Apodized Spiral Contra-Directional Couplers, Mustafa Hammood[1], Stephen Lin[1], Ajay Mistry[1], Minglei Ma[1], Lukas Chrostowski[1], Nicolas Jaeger[1]; [1]*Univ. of British Columbia, Canada.* We use long, spiral contra-directional couplers (contra-DCs) to make optical add-drop filters with 30 dB extinction ratios and 12.2 nm bandwidths, and avoid some of the effects caused by fabrication non-uniformities in long, straight contra-DCs.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM3K • A&T Topical Review on Flat Optics I—Continued

AM3K.5 • 15:00 Invited
Optical Power Limiters Based on Intersubband Polaritonic Metasurfaces, Nishant Nookala[1], Sander Mann[2], Ahmed Mekkawy[2], John F. Klem[3], Igal Brener[3], Andrea Alu[2], Mikhail A. Belkin[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Advanced Science Research Center, City Univ. of New York , USA;* [3]*Sandia National Labs, USA.* We present a novel class of power limiting polaritonic metasurfaces exploiting saturable intersubband absorption in semiconductor quantum wells coupled to plasmonic resonators. Power limiting is experimentally verified and the metasurface performance limits are theoretically analyzed.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM3L • Fiber Amplifiers—Continued

SM3L.4 • 15:00
620 nm Source by Second Harmonic Generation of a Phosphosilicate Raman Fiber Amplifier, Anita M. Chandran[1], Timothy H. Runcorn[1], Robert T. Murray[1], James R. Taylor[1]; [1]*Imperial College London, UK.* We demonstrate a nanosecond-pulsed 620 nm source through frequency doubling a 1240 nm phosphosilicate Raman fiber amplifier. The source emits up to 213 mW of average power, and is repetition rate and pulse duration tunable.

SM3L.5 • 15:15
All-fiber polarization maintaining Thulium doped amplifier seeded by coherent polarized supercontinuum, Anupamaa Rampur[1,2], Grzegorz Stepniewski[1], Dominik Dobrakowski[1,2], Yuriy Stepanenko[3], Alexander Heidt[4], Thomas Feurer[4], Mariusz Klimczak[3,2]; [1]*Inst of Electronic Materials Technology, Poland;* [2]*Faculty of Physics, Univ. of Warsaw, Poland;* [3]*Laser Center, Inst. of Physical Chemistry, Polish Academy of Sciences, Poland;* [4]*Inst. of Applied Physics, Univ. of Bern, Switzerland.* Coherently seeded, broadband ultrafast thulium fiber amplifier is demonstrated. Its architecture comprises only polarization-maintaining fibers. Preliminary results show amplification of 2 nJ, 5.5ps long, 100 nm (3dB) pulses centered at 1900 nm before recompression.

14:30–16:00 Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, *Guadalupe Room, San Jose Marriott*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

16:00–17:30 Professional Development for Busy Professionals, *Salon VI, San Jose Marriott*

Joint

JM3M • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect I—Continued

JM3M.4 • 15:00
Optimization of Nonlinear Nanophotonic Media for Artificial Neural Inference, Erfan Khoram[1], Ang Chen[1], Dianjing Liu[1], Qiqi Wang[2], Ming Yuan[3], Zongfu Yu[1]; [1]*Univ. of Wisconsin-Madison, USA;* [2]*MIT, USA;* [3]*Columbia Univ., USA.* We show optical waves passing through a nanophotonic medium can perform artificial neural computing. Such a medium exploits linear and nonlinear scatterers to realize complex input-output mapping far beyond the capabilities of traditional nanophotonic devices.

JM3M.5 • 15:15
PhaseStain: Deep Learning-based Histological Staining of Quantitative Phase Images, Yair Rivenson[1], Tairan Liu[1], Zhensong Wei[1], Kevin de Haan[1], Yibo Zhang[1], Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* We demonstrate a digital staining framework that transforms quantitative phase images of label-free tissue sections to match the brightfield microscopy images of the same sections, after histological staining. Inference of multiple tissue-stain combinations is demonstrated.

CLEO: Science & Innovations

SM3N • Novel Optoelectronic Devices—Continued

SM3N.7 • 15:00
Dual-wavelength operation of the GaSb-based diode lasers with asymmetric coupled quantum wells, Jiang Jiang[1], Leon Shterengas[1], Takashi Hosoda[1], Aaron Stein[2], Alexey Belyanin[3], Gela Kipshidze[1], Gregory Belenky[1]; [1]*Stony Brook Univ., USA;* [2]*Center for Functional Nanomaterials, Brookhaven National Lab, USA;* [3]*Physics, Texas A&M Univ., USA.* The DBR diode lasers with asymmetric tunnel coupled quantum wells having built-in resonant second order nonlinearity were designed and fabricated. The devices can generate comparable power in two bands near 2 um separated by ~13 meV as required for intracavity difference frequency generation.

SM3N.8 • 15:15
Optically-feedbacked mode-locked laser diode for tunable narrow-linewidth photonic millimeter-wave generation, Huan Wang[1], Lu Guo[1], Wu Zhao[1], Guangcan Chen[1], Dan Lu[1], Lingjuan Zhao[1]; [1]*Inst. of Semiconductors, Chinese Academy of Science, China.* A tunable narrow-linewidth photonic millimeter-wave generation scheme is demonstrated by using a mode-locked laser diode with optical feedback. Photonic mode beating signal tunable from 42GHz to 293GHz with a linewidth of several kHz is obtained.

SM3O • Guided Wave Nonlinear Devices—Continued

SM3O.6 • 15:00
Direct Mode-Frequency Control for Nonlinear Optics in Photonic-Crystal Ring Resonators, Su-Peng Yu[1,2], Hojoong Jung[1,2], Travis C. Briles[1,2], David Carlson[1], Gregory Moille[3], Xiyuan Lu[3], Kartik Srinivasan[3], Scott B. Papp[1,2]; [1]*Time and Frequency Division, NIST Boulder, USA;* [2]*Physics, Univ. of Colorado Boulder, USA;* [3]*Center for Nanoscale Science and Technology, NIST Gaithersburg, USA.* We demonstrate that photonic-crystal modulation enables individual mode-frequency shifting in ring resonators, and high quality factor. Simulation predicts frequency-comb generation in normal-dispersion resonators and spontaneous pulse formation in both dispersion types.

14:30–16:00 Deliberate Mentoring to Advance Your Career: Special Flash Mentoring Session, *Guadalupe Room, San Jose Marriott*

15:30–16:00 Coffee Break, *Concourse Level*

16:00–17:00 Resumes, Linkedin, and Networking (with Cheeky Scientist), *University Room, Hilton San Jose*

16:00–17:30 Professional Development for Busy Professionals, *Salon VI, San Jose Marriott*

CLEO: QELS-Fundamental Science

16:00–18:00
FM4A • Quantum Nanophotonics II: Diamond & Boron Nitride
Presider: Glenn Solomon; Joint Quantum Institute, USA

FM4A.1 • 16:00
Quantum Optics with Tin-Vacancy Emitters in Diamond, Matthew Trusheim[1], Benjamin Pingault[2], Noel Wan[1], Mustafa Gundogan[2], Lorenzo de Santis[1], Kevin Chen[1], Mete Atature[2], Dirk R. Englund[1]; *[1]MIT, USA; [2]Cavendish Lab, Univ. of Cambridge, UK.* We investigate the quantum optical properties of single tin-vacancy emitters in diamond through resonant magneto-optical spectroscopy at 4 K. We find radiative lifetime-limited optical transitions associated with long-lived spin states.

FM4A.2 • 16:15
Optical Characterization of Single Tin-Vacancy Centers in Diamond Nanopillars, Alison E. Rugar[1], Constantin Dory[1], Shuo Sun[1], Jelena Vuckovic[1]; *[1]Stanford Univ., USA.* We characterize the optical and spin properties of tin-vacancy centers isolated in diamond nanopillars. We measure spectrometer-limited linewidths <15 GHz, a strong polarization dependence of the emission, and Zeeman splitting behavior consistent with previous theoretical predictions.

FM4A.3 • 16:30 Invited
Control and Stabilization of Nitrogen-Vacancy Centers in Photonic Circuits, Kai-Mei Fu[1]; *[1]Univ. of Washington, USA.* We present our results integrating near-surface nitrogen-vacancy (NV) centers into gallium phosphide (GaP) photonic circuits toward photon-mediated spin-spin entanglement.

16:00–18:00
FM4B • Topological Photonics II
Presider: Zubin Jacob; Purdue University, USA

FM4B.1 • 16:00
Depopulation of Edge States under Local Periodic Driving despite Topological Protection, Christina I. Jörg[1], Zlata Cherpakova[2], Christoph Dauer[1], Fabian Letscher[1,3], Michael Fleischhauer[1], Sebastian Eggert[1], Stefan Linden[2], Georg von Freymann[1,4]; *[1]Physics, TU Kaiserslautern, Germany; [2]Physikalisches Insitut, Universität Bonn, Germany; [3]Graduate School Materials Science in Mainz, Germany; [4]Fraunhofer Inst. for Industrial Mathematics ITWM, Germany.* We show that edge states can be depopulated despite their topological protection. Local time-periodic driving results in hybridization of edge and bulk states for certain driving frequencies. Experiments are performed using plasmonic and dielectric waveguides.

FM4B.2 • 16:15
Demonstration of a Photonic Topological Z2-Insulator, Lukas Maczewsky[1], Bastian Höckendorf[2], Mark Kremer[1], Tobias Biesenthal[1], Matthias Heinrich[1], Andreas Alvermann[2], Holger Fehske[2], Alexander Szameit[1]; *[1]Inst. of Physics, Univ. of Rostock, Germany; [2]Inst. of Physics, Univ. of Greifswald, Germany.* We introduce a photonic topological Floquet Z2-insulator with fermionic time reversal symmetry (TRS). Our experiments demonstrate the characteristic protected counter-propagating edge modes and unequivocally prove the presence of fermionic TRS in this bosonic system.

FM4B.3 • 16:30
Supersymmetric transformations of photonic topological systems, Gerard Queraltó Isach[1], Mark Kremer[2], Matthias Heinrich[2], Verònica Ahufinger[1], Jordi Mompart[1], Alexander Szameit[2]; *[1]Universitat Autonoma de Barcelona, Spain; [2]Universität Rostock, Germany.* We explore the interplay between supersymmetry and topology by applying supersymmetric transformations to a photonic lattice supporting topologically protected states. These transformations change the spectrum of the system, leading to topological transitions.

16:00–18:00
FM4C • New Systems for Quantum Communications
Presider: Thomas Gerrits; NIST, USA

FM4C.1 • 16:00
Satellite based Quantum key distribution using a compact terminal on Tiangong-2 Space lab, Shengkai Liao[1,2], Jin Lin[1,2], Jigang Ren[1,2], Weiyue Liu[1,2], Juan Yin[1,2], Yang Li[1,2], Yuan Cao[1,2], Qi Shen[1,2], Fengzhi Li[1,2], Wenqi Cai[1,2], Cheng-Zhi Peng[1,2], Jian-Wei Pan[1,2]; *[1]Univ. of Science and Technology of China, Hefei National Lab for Physical Sciences at the Microscale and Dept. of Modern Physics, China; [2]Shanghai Branch, CAS Center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, China.* We report a quantum key distribution experiment using a compact terminal on Tiangong-2 spacecraft two years after launch. This robust platform provides an effective solution for realizing a practical satellite-constellation-based global quantum secure network.

FM4C.2 • 16:15
A Daytime Free-Space Quantum-Optical Link using Atomic-Vapor Spectral Filters, Christopher C. Evans[1], David N. Woolf[1], Justin M. Brown[1], Joel M. Hensley[1]; *[1]Physical Sciences Inc., USA.* We establish a free-space quantum-optical link that leverages narrow (~1 GHz) linewidth rubidium-based bandpass filters to drastically reduce solar background. To show its utility, we demonstrate the BB84 quantum key distribution protocol under daytime conditions.

FM4C.3 • 16:30
Measurement-device-independent QKD over asymmetric channels, Hui Liu[1,2], Wenyuan Wang[3], Kejin Wei[1,2], Xiao-Tian Fang[1,2], Li Li[1,2], Nai-Le Liu[1,2], Hao Liang[1,2], Si-Jie Zhang[1,2], Weijun Zhang[4], Hao Li[4], Lixing You[1], Zhen Wang[4], Hoi-Kwong Lo[3], Teng-Yun Chen[1,2], Feihu Xu[1,2], Jian-Wei Pan[1,2]; *[1]Shanghai Branch, Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China; [2]CAS Center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, Univ. of Science and Technology of China, China; [3]Centre for Quantum Information and Quantum Control (CQIQC), Dept. of Electrical \& Computer Engineering and Dept. of Physics, Univ. of Toronto, Canada; [4]State Key Lab of Functional Materials for Informatics, Shanghai Inst. of Microsystem and Information Technology, Chinese Academy of Sciences, China.* We propose and demonstrate an efficient protocol that enables a scalable high-rate measurement-device-independent (MDI) QKD over asymmetric channels. The theoretical and experimental results unleash the full potential of MDI-QKD in practical network settings.

16:00–18:00
FM4D • Excitons in Condensed Matter Systems
Presider: Denis Seletskiy; Polytechnique Montréal, Canada

FM4D.1 • 16:00
Observation of Narrow-Band Terahertz Gain in Two-Dimensional Magnetoexcitons, Xinwei Li[1], Katsumasa Yoshioka[2], Qi Zhang[3], Fumiya Katsutani[1], Weilu Gao[1], Nicolas Marquez[1], Tim Noe[1], John Watson[4], Michael Manfra[4], Ikufumi Katayama[2], Jun Takeda[2], Junichiro Kono[1]; *[1]Rice Univ., USA; [2]Yokohama National Univ., Japan; [3]Argonne National Labs, USA; [4]Purdue Univ., USA.* We have performed time- and polarization-resolved optical-pump—terahertz-probe magnetospectroscopy measurements on a GaAs quantum well and observed narrow-band, polarization-selective THz gain, whose center frequency shifts with applied magnetic field.

FM4D.2 • 16:30
Optical valley-Hall effect of 2D excitons, Sriram Guddala[1], Mandeep Khatoniar[1,2], Nicholas Yama[1], Vinod Menon[1,2]; *[1]City College of New York, USA; [2]Physics, 2Graduate Center, City Univ. of New York (CUNY), New York, USA, USA.* We demonstrate optical analogue of valley-Hall effect for 2D materials by achieving unidirectional coupling of valley polarized excitonic emission to large wavevector modes in hyperbolic metamaterials.

Executive Ballroom 210E

Executive Ballroom 210F

Executive Ballroom 210G

Executive Ballroom 210H

CLEO: Science & Innovations

16:00–18:00
SM4E • High-Average Power Laser Systems
Presider: Emily Sistrunk Link; Lawrence Livermore National Laboratory, USA

SM4E.1 • 16:00
Joule-class 500 Hz Cryogenic Yb:YAG Chirped Pulse Amplifier, Luis E. Zapata[1], Simon Schweistal[1], Jelto Thesinga[1], Collette Zapata[1], Matthias Schust[1], Liu Yizhou[1], Mikhail Pergament[1], Franz Kartner[1,2]; *[1]Center for Free Electron Laser Science, Germany; [2]Dept. of Physics & The Hamburg Center for Ultrafast Imaging, Univ. of Hamburg, Germany.* A cryogenic Yb:YAG composite-thin-disk laser driver has demonstrated long-term stable operation at 500 Hz with 1-joule 20-ns pulses. Results with chirped pulses will be presented. Joule-level pulses at 500 Hz compressible to 5 ps are expected.

SM4E.2 • 16:30
High Peak and Average Power Yb-doped Tapered Fiber Amplifier, Konstantin K. Bobkov[1], Andrey E. Levchenko[1], Vladimir V. Velmiskin[1], Tatiana A. Kochergina[1], Svetlana Aleshkina[1], Mikhail Bubnov[1], Denis Lipatov[2], Alexei Guryanov[2], Mikhail Likhachev[1]; *[1]Fiber Optics Research Center RAS, Russia; [2]Inst. of High Purity Substances of the RAS, Russia.* Yb-doped tapered fiber amplifier delivering picosecond pulses with both high peak power (550 kW) and high average power (44 W) is presented.

16:00–18:00
SM4F • Precision Spectroscopy
Presider: Laura Sinclair, NIST, USA

SM4F.1 • 16:00 Tutorial
Challenging QED with atomic Hydrogen, Thomas Udem[1], Lothar Maisenbacher[1], Axel Beyer[1], Vitaly Andreev[1], Alexey Grinin[1], Arthur Matveev[1], Ksenia Khabarova[1], Nikolai Kolachevsky[1], Randolf Pohl[1], Dylan Yost[1], Theodor Hänsch[1]; *[1]Max-Planck-Institut fur Quantenoptik, Germany.* Testing theories means to compare precise measurements with theoretical predictions. I will describe where we stand with quantum electrodynamics by verifying calculations of energy levels in atomic hydrogen.

Thomas Udem studied physics at the University of Giessen and at the University of Washington. In 1997 he got his PhD from the University of Munich (LMU). After a short post doc at the NIST Boulder he returned Munich where became a research fellow MPQ and since 2016 professor at LMU.

16:00–17:15
SM4G • Access & Radio Over Fiber
Presider: Ryan Scott; Keysight Laboratories. USA

SM4G.1 • 16:00
SOA-based Metro-Access Coherent Transmission Systems , Giuseppe Talli[1], Cleitus Antony[1], Mark Power[1], Paul Townsend[1]; *[1]Tyndall National Inst., Ireland.* SOAs are demonstrated as in-line amplifiers in a metro-access system with potential for dynamic reconfiguration and traffic convergence with 5 spans of 40km of SMF and up to 7x200Gb/s DP-16QAM channels using 9 concatenated SOAs.

SM4G.2 • 16:15
Bidirectional fiber transmission of mmW signals using remote downconversion and wavelength reuse, Aleksandra Kaszubowska-Anandarajah[1], Amol Delmade[2], Eamonn Martin[2], Prince M. Anandarajah[2], Liam P. Barry[2], Colm Browning[2]; *[1]Connect Centre, Trinity College Dublin, Ireland; [2]School of Electronic Engineering, Dublin City Univ., Ireland.* We demonstrate an RoF system with a simplified RRU, by employing a remote uplink downconversion and downlink wavelength reuse. An error-free transmission of 64-QAM UF-OFDM signals over 12 km of fiber is also shown.

SM4G.3 • 16:30
A Timing-synchronization-free WDM-compatible Colorless DRoF Uplink System for 5G Mobile Fronthaul Employing Gold Sequence Multiplexing, Jhih-Heng Yan[1], Chao-Wei Wang[1], Kai-Hsiang Lin[1], Kai-Ming Feng[1]; *[1]National Tsing Hua Univ., Taiwan.* A Timing-synchronization-free WDM-compatible Colorless DRoF Uplink for 5G Mobile Fronthaul employing Gold sequence multiplexing is experimentally demonstrated. Both signals at different wavelengths with total 6-Gb/s throughput are retrieved without timing synchronization or WDM demultiplexing.

16:00–18:00
SM4H • Advanced Optical Technologies for Cells and Tissues
Presider: Jessica Houston; New Mexico State Univ., USA

SM4H.1 • 16:00
Intelligent Image-Activated Cell Sorting and Beyond, Yasuyuki Ozeki[1], Nao Nitta[1,2], Takeaki Sugimura[1,2], Akihiro Isozaki[1], Hideharu Mikami[1], Dino Di Carlo[3], Yoichiroh Hosokawa[4], Sotaro Uemura[1], Keisuke Goda[1]; *[1]Univ. of Tokyo, Japan; [2]Japan Science and Technology Agency, Japan; [3]Univ. of California, Los Angeles, USA; [4]Nara Inst. of Science and Technology, Japan.* We present a groundbreaking machine intelligence technology called "intelligent image-activated cell sorting" that achieves high-throughput image-triggered sorting of single cells by integrating high-speed fluorescence microscopy, cell focusing, cell sorting, and deep learning.

SM4H.2 • 16:30
Portable Imaging Flow-cytometer Using Deep Learning-based Holographic Image Reconstruction, Zoltán Göröcs[1], Miu Tamamitsu[1], Vittorio Bianco[1], Patrick Wolf[1], Shounak Roy[1], Koyoshi Shindo[1], Kyrollos Yanny[1], Yichen Wu[1], Hatice Ceylan Koydemir[1], Yair Rivenson[1], Aydogan Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* We demonstrate deep learning assisted holographic imaging of waterborne microorganisms in color using a field-portable flow-cytometer capable of high-throughput screening of flowing water samples and report its capabilities using ocean samples containing plankton.

Meeting Room 211 A/B

CLEO: Applications & Technology

16:00–18:00
AM4I • Nanobiophotonics
Presider: Andrea Armani; University of Southern California, USA

AM4I.1 • 16:00
Wide-field magnetic imaging of sub-50 nm ferromagnetic nanoparticles for time-resolved bio-mechanical orientation measurements, Zeeshawn Kazi[1], Isaac Shelby[1], Nicholas Brunelle[1], Hideyuki Watanabe[4,6], Kohei M. Itoh[5,6], Paul Wiggins[1,3], Kai-Mei Fu[1,2]; [1]*UW Physics Dept., USA;* [2]*Electrical Engineering, Univ. of Washington, USA;* [3]*Bioengineering, Univ. of Washington, USA;* [4]*Electronics and Photonics Research Inst., National Inst. of Advanced Industrial Science and Technology (AIST), Japan;* [5]*School of Fundamental Science and Technology, School of Fundamental Science and Technology, Japan;* [6]*Spintronics Research Center, Keio Univ., Japan.* We image the stray magnetic field of commercial chemically functionalized ferromagnetic cobalt nanoparticles using optically detected magnetic resonance of a near- surface ensemble of nitrogen vacancy centers in diamond.

AM4I.2 • 16:15
Nanoplasmonic Interferometric Sensor for Multiplex Detection of MMP-9 and TIMP-1, Yifeng Qian[1], Yu-Han Ho[2], Sushil Kumar[1], Xuanhong Cheng[3], Filbert Bartoli[1]; [1]*Electrical and Computer Engineering Dept., Lehigh Univ., USA;* [2]*Shanghai Industrial μTechnology Research Inst., China;* [3]*Bioengineering Dept., Lehigh Univ., USA.* The secretion of MMP-9 and TIMP-1 was detected simultaneously using a nanoplasmonic interferometric sensor. Dynamic and multiplexed sensing of two secretory proteins suggests the biosensor holds good promise for cell function analysis.

AM4I.3 • 16:30
Holographic Microscopy with Acoustic Modulation for Detection of Nano-sized Particles and Pathogens in Solution, Aniruddha Ray[1], Muhammad A. Khalid[2], Andriejus Demcenko[2], Mustafa Daloglu[1], Derek Tseng[1], Julien Reboud[2], Jonathan Cooper[2], Aydogan Ozcan[1]; [1]*Univ. of California, USA;* [2]*Univ. of Glasgow, UK.* We present a method for the detection of nanoparticles in solution using an acoustically actuated holographic microscope. This type of microscopy can be used for high-throughput biosensing applications, e.g., detection of viruses in a liquid.

Meeting Room 211 C/D

CLEO: Science & Innovations

16:00–18:00
SM4J • Light Emission & Detection
Presider: Andrew Young; Bristol Univ., UK

SM4J.1 • 16:00 Invited
Single-carbon-nanotube Photonics and Optoelectronics, Yuichiro K. Kato[1]; [1]*RIKEN, Japan.* Single-walled carbon nanotubes exhibit telecom-band emission at room temperature and they can be directly synthesized on silicon substrates. Here we discuss the use of individual carbon nanotubes for generation and manipulation of photons on a chip.

SM4J.2 • 16:30
Graphene-Based Transparent Photodetector Array for Multiplane Imaging, Dehui Zhang[1], Zhen Xu[1], Zhengyu Huang[1], Audrey Rose Gutierrez[1], Il Yong Chun[1], Cameron J. Blocker[1], Gong Cheng[1], Zhe Liu[1], Jeffrey A. Fessler[1], Zhaohui Zhong[1], Theodore B. Norris[1]; [1]*Univ. of Michigan, USA.* We report a transparent photodetector array using graphene as both the active pixel and interconnect material. We demonstrate imaging at multiple focal planes with these arrays. Further applications of position tracing will also be discussed.

Meeting Room 212 A/B

CLEO: Applications & Technology

16:00–18:00
AM4K • A&T Topical Review on Flat Optics II
Presider: To Be Announced

AM4K.1 • 16:00 Invited
Dispersion-engineered and Polarization-insensitive Metasurfaces for Broadband Achromatic Optics, Wei-Ting Chen[1], Federico Capasso[1]; [1]*Harvard Univ., USA.* Chromatic aberrations are challenging to correct. We show dispersion-tailored and polarization-insensitive metasurfaces comprising anisotropic nanofins that can correct the chromatic aberrations in lens systems (from singlet lenses to sophisticated microscope objectives) with unprecedented compactness.

AM4K.2 • 16:30 Invited
Metasurface Devices for AR/VR, Byoungho Lee[1], Gun-Yeal Lee[1], Jong-Young Hong[1]; [1]*Electrical and Computer Engineering, Seoul National Univ., South Korea (the Republic of).* We introduce recent achievements on metasurface optical applications. In particular, metasurface holography with full complex-amplitude holograms and metalens for augment reality display with large viewing angles are discussed and their outlook is also discussed.

Meeting Room 212 C/D

CLEO: Science & Innovations

16:00–17:30
SM4L • Specialty Fibers
Presider: Guoqing Chang; Institute of Physics, CAS, China

SM4L.1 • 16:00 Invited
Hybrid Fibers for Dispersion Management at 1 μm, Svetlana Aleshkina[1], Mikhail Yashkov[2], Mikhail Salganskii[2], Denis Lipatov[2], Liudmila Iskhakova[1], Mikhail Bubnov[1], Alexei Guryanov[2], Mikhail Likhachev[1]; [1]*Fiber Optics Res. Ctr the RAS, Russia;* [2]*Inst. of High Purity Substances of the Russian Academy of Sciences, Russia.* Hybrid fibers with high (60-400 ps/(nm×km)) anomalous dispersion at 1.06 μm were developed. Utilization of such fibers allowed us to fabricate femtosecond all-fiber master oscillator and nonlinear chirped pulses compressor (P_{peak}> 3 kW).

SM4L.2 • 16:30
Efficient High-power Single-mode Yb Three-level Cladding-pumped All-solid Photonic Bandgap Fiber Lasers at ~978nm, Turghun Matniyaz[1], Wensong Li[1,2], Monica Kalichevsky-Dong[1], Thomas Hawkins[1], Joshua Parsons[1], Guancheng Gu[3], Liang Dong[1]; [1]*Clemson Univ., USA;* [2]*Dept. of Electronic Engineering, Xiamen Univ., China;* [3]*Coherent/Nufern, USA.* We report an efficiency of 62.7% with regard to the launched pump from a Yb cladding-pumped fiber laser at ~978nm. ~84W with an M^2 of 1.11/1.12 was achieved, a significant improvement from a flexible fiber.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

16:00–18:00
FM4M • Solid State High Harmonic Generation
Presider: Hanieh Fattahi; Max Planck Institute for Quantum Optics, Germany

FM4M.1 • 16:00
High Harmonic Generation in Reflection and Transmission from Gallium Arsenide, Nobuhisa Ishii[1], Peiyu Xia[1], Changsu Kim[1], Faming Lu[1], Teruto Kanai[1], Hidefumi Akiyama[1], Jiro Itatani[1]; [1]*Inst. for Solid State Physics, Japan.* High harmonic generation in reflection and transmission from gallium arsenide is investigated using femtosecond infrared pulses. Harmonic spectra obtained in both geometries show drastic difference with each other, indicating significant contribution of nonlinear propagation.

FM4M.2 • 16:15
Modeling Harmonic Generation in Polycrystalline ZnSe, Michael G. Hastings[1], Kevin Werner[2], Aaron Schweinsberg[3], Brian L. Wilmer[4], Drake Austin[2], Christopher Wolfe[5], Trenton Ensley[6], Laura Vanderhoef[5], Anthony Valenzuela[5], Enam Chowdhury[2], Jerome V. Moloney[1], Miroslav Kolesik[1]; [1]*College of Optical Sciences, Univ. of Arizona, USA;* [2]*Dept. of Physics, The Ohio State Univ., USA;* [3]*Oak Ridge Inst. for Science and Education, USA;* [4]*SURVICE Engineering, USA;* [5]*Weapons and Materials Research Directorate, U.S. Army Resarch Lab, USA;* [6]*Sensors and Electron Devices Directorate, U.S. Army Research Lab, USA.* High harmonic generation in polycrystalline ZnSe is modeled as an effective medium. The non-perturbative behavior observed experimentally was recreated, showing that an effective model captures the underlying physics.

FM4M.3 • 16:30 Invited
Dipole Phase of High-harmonics from Crystals, Yongsing You[1]; [1]*Stanford Univ., USA.* Abstract not available.

Marriott
Salon III

CLEO: Science & Innovations

16:00–18:00
SM4N • Surface Emitting Lasers
Presider: To Be Announced

SM4N.1 • 16:00 Invited
Blue and Ultraviolet Vertical-cavity Surface-emitting Lasers, Åsa Haglund[1], Michael Bergmann[1], Filip Hjort[1], Ehsan Hashemi[1], Jörgen Bengtsson[1], Johan Gustavsson[1]; [1]*Chalmers Univ. of Technology, Sweden.* We will summarize state-of-the-art results in III-nitride-based vertical-cavity surface-emitting lasers (VCSELs) for blue and ultraviolet emission, including our schemes for optically guided devices and our approach for UV-VCSELs with double dielectric distributed Bragg reflectors.

SM4N.2 • 16:30
Beam Pattern Projecting On-Chip Lasers at Visible Wavelength, Yoshitaka Kurosaka[1], Kazuyoshi Hirose[1], Akio Ito[1], Masahiro Hitaka[1], Akira Higuchi[1], Takahiro Sugiyama[1], Yu Takiguchi[1], Yoshiro Nomoto[1], Soh Uenoyama[1], Tadataka Edamura[1]; [1]*Hamamatsu Photonics, Japan.* We have successfully demonstrated pattern projecting semiconductor lasers at the red wavelength, for the first time. The two-dimensional pattern was directly emitted on the screen, at the red wavelength, without any lens or scanning system.

Marriott
Salon IV

16:00–18:00
SM4O • Nonlinear Phonon Interactions
Presider: Amol Choudhary Indian Institute of Technology Delhi, India

SM4O.1 • 16:00
Higher Order Cascaded SBS Suppression Using Gratings in a Photonic Integrated Ring Resonator Laser, Matthew Puckett[2], Debapam Bose[1], Karl Nelson[2], Daniel Blumenthal[1]; [1]*Univ. of California, Santa Barbara, USA;* [2]*Honeywell International, USA.* An integrated Brillouin laser that maintains lasing in only the first Stokes order with up to 1W input pump power is demonstrated by incorporating Bragg gratings in the resonator waveguide.

SM4O.2 • 16:15
On-Chip Stimulated Brillouin Lasers Based on Chalcogenide Glass Resonators with 10 Million Q-factor, Sangyoon Han[1], Dae-Gon Kim[2], Joonhyuk Hwang[1], In Hwan Do[2], Dongin Jeong[2], Yong-Hee Lee[1], Duk-yong Choi[3], Hansuek Lee[2]; [1]*Dept. of Physics, South Korea Advanced Inst. of Science and Technology, South Korea (the Republic of);* [2]*Graduate School of Nanoscience and Technology, South Korea Advanced Inst. of Science and Technology, South Korea (the Republic of);* [3]*Laser Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia.* On-chip chalcogenide glass resonator with Q-factor of 1.08×10^7 is experimentally demonstrated with a new fabrication approach which avoids direct etch process. Waveguide-coupled stimulated Brillouin laser with 2.5 mW threshold power is implemented by flip-chip coupling.

SM4O.3 • 16:30
Arbitrary Optical Waveform Generation by Nonlinear Frequency-to-Time Conversion, Daniel E. Mittelberger[1], Ryan Muir[1], Mathew Hamamoto[1], Matthew Prantil[1], John Heebner[1]; [1]*Lawrence Livermore Natl Lab, USA.* We propose and demonstrate a novel method of arbitrary optical temporal pattering for generation of long (330 ps) unchirped waveforms with picosecond features. The method is based on frequency-to-time conversion of an imposed spectral pattern.

CLEO: QELS-Fundamental Science

FM4A • Quantum Nanophotonics II: Diamond & Boron Nitride—Continued

FM4A.4 • 17:00
Frequency Tunable Single-Photon Emission From a Single Atomic Defect in a Solid, Shuo Sun[1], Linda Jingyuan Zhang[1], Kevin Fischer[1], Michael Burek[2], Constantin Dory[1], Konstantinos Lagoudakis[1], Yan-Kai Tzeng[1], Marina Radulaski[1], Yousif Kelaita[1], Amir Safavi-Naeini[1], Zhi-Xun Shen[1], Nicholas Melosh[1], Steven Chu[1], Marko Loncar[2], Jelena Vuckovic[1]; *[1]Stanford Univ., USA; [2]Harvard Univ., USA.* We demonstrate generation of frequency tunable single-photon emission based on cavity-enhanced Raman emission from a single silicon-vacancy center in diamond. The demonstrated frequency tuning range (100 GHz) significantly exceeds the spectral inhomogeneity of the emitters.

FM4A.5 • 17:15
Tuning of Quantum Emitters in Hexagonal Boron Nitride, Noah Mendelson[1], Niko Nikolay[2,3], Zai-Quan Xu[1], Trong Toan Tran[1], Nikola Sadzak[2,3], Florian Bohm[2,3], Bernd Sontheimer[2,3], Oliver Benson[2,3], Milos Toth[1], Igor Aharonovich[1]; *[1]Univ. of Technology Sydney, Australia; [2]AG Nanooptik, Humboldt Universitat zu Berlin, Germany; [3]IRIS Adlershof, Humboldt Universitat zu Berlin, Germany.* We demonstrate two different techniques to tune quantum emitters in hBN, achieving record tuning magnitudes for a solid state quantum emitter, as well as dynamic and reversible modulation of the emitters through both methods).

FM4A.6 • 17:30 Invited
Probing Spin Transfer Effects with Diamond Defects, Lilian Childress[1], Adrian Solyom[1], Zackary Flansberry[1], Marta Tschudin[2], Nathaniel Leitao[1,4], Michel Pioro-Ladriere[3,4], Jack Sankey[1]; *[1]McGill Univ., Canada; [2]Univ. of Basel, Switzerland; [3]Univ. of Sherbrooke, Canada; [4]CIFAR, Canada.* A single NV center is used to detect effects of damping and anti-damping spin transfer torques on a proximal magnetic nanowire.

FM4B • Topological Photonics II—Continued

FM4B.4 • 16:45
Photonic bands in 230 space groups, Ling Lu[1], Haruki Watanabe[2]; *[1]Inst. of Physics, Chinese Academy of Sciences, China; [2]Dept. of Applied Physics, Univ. of Tokyo, Japan.* We present the symmetry constraints on photonic bands for all 230 space groups with time-reversal symmetry. The results of minimum band connectivities provide useful design insights for photonic crystals, metamaterials, and topological lattices.

FM4B.5 • 17:00
Angular momentum-dependent topological transport, Meng Xiao[1], Tianshu Jiang[2], Wen-jie Chen[3], Yawen Fang[2], Wing Yim Tam[2], Che Ting Chan[2]; *[1]School of Physics and Technology, Wuhan Univ., China; [2]Dept. of Physics, the Hong Kong Univ. of Science and Technology, Hong Kong; [3]School of Physics and Engineering, Sun Yat-Sen Univ., China.* Analogs of the quantum spin Hall effect (QSHE) in classical waves are mostly based on the construction of pseudo-spins. Here we demonstrate analogs of QSHE in classical waves by utilizing the orbital angular momentum.

FM4B.6 • 17:15
Non-scattering Systems for Field Localization and Emission Enhancement, Viktar Asadchy[1], Francisco Cuesta[1], Mohammad Mirmoosa[1], Sergei Tretyakov[1]; *[1]Electronics and Nanoengineering, Aalto Univ., Finland.* We propose invisible cavities which do not scatter electromagnetic waves under normal incidence but strongly enhance or suppress the fields inside. They can be used for cloaking sensors and emission enhancement of wave sources.

FM4B.7 • 17:30
Observation of Local Symmetry in a Photonic System, Nora Schmitt[1], Steffen Weimann[1], Christian Morfonios[2], Malte Roentgen[2], Matthias Heinrich[1], Peter Schmelcher[2,3], Alexander Szameit[1]; *[1]Inst. of Physics, Univ. of Rostock, Germany; [2]Center for Optical Quantum Technologies, Univ. of Hamburg, Germany; [3]Hamburg Centre for Ultrafast Imaging, Univ. of Hamburg, Germany.* We demonstrate the effect of local symmetries on the dynamics of laser-written photonic waveguide arrays. A non-local continuity equation allows us to distinguish between the three cases of global symmetry, local symmetry and full disorder.

FM4C • New Systems for Quantum Communications—Continued

FM4C.4 • 16:45
Integrated photonic devices for measurement-device-independent quantum key distribution, Henry Semenenko[1,2], Philip Sibson[2], Mark G. Thompson[2], Chris Erven[2]; *[1]H. H. Wills Physics Lab \& Dept. of Electrical and Electronic Engineering, Quantum Engineering Centre for Doctoral Training, UK; [2]H. H. Wills Physics Lab \& Dept. of Electrical and Electronic Engineering, Quantum Engineering Technology Labs, UK.* We experimentally demonstrate integrated photonic devices for measurement device independent quantum key distribution with state-of-the-art error and clock rates which will lead to more cost effective, practical and secure communication.

FM4C.5 • 17:00
Field Trial of Long Distance Quantum Key Distribution with Polarization Encoding Througth Installed Aerial Fibe, Dong-Dong Li[2,1], Song Gao[1], Guo-Chun Li[3], Lu Xue[4], Li-Wei Wang[1], Chang-Bin Lu[1], Yao Xiang[1], Zi-Yan Zhao[3], Long-Chuan Yan[3], Zhi-Yu Chen[3], Gang Yu[1], Jianhong Liu[1,4]; *[1]Quantum CTek, China; [2]Univ. of Science and Technology of China, China; [3]State Grid Information & Telecommunication Co., Ltd, China; [4]QuantumCTek (Beijing), China.* We experimentally demonstrate quantum key distribution with polarization encoding through installed aerial fiber link. The fast vibration of polarization is compensated with a homemade feedback module. The key rate reaches 2 kbps over 68-km-long fiber.

FM4C.6 • 17:15
Entangled Photon Transmission from a Quantum Dot over Loop-back Fiber in Cambridge Network, Zi-Heng Xiang[2,1], Jan Huwer[2], R. Mark Stevenson[2], Joanna Skiba-Szymanska[2], Martin Ward[2], Ian Farrer[3,1], David Ritchie[1], Andrew Shields[2]; *[1]Univ. of Cambridge, UK; [2]Toshiba Research Europe Ltd, UK; [3]Univ. of Sheffield, UK.* We report the long-term transmission of high-fidelity entangled photons emitted from a telecom wavelength quantum dot device over the Cambridge Fiber Network with a time-multiplexed polarization stabilization system.

FM4C.7 • 17:30
Toward Experimental Implementation of Quantum-Enabled, Bandwidth and Power Efficient Communications, Ivan A. Burenkov[1,2], M.V. Jabir[2], Driss El Idrissi[2], Abdella Battou[2], Sergey V. Polyakov[2]; *[1]Joint Quantum Inst., USA; [2]NIST, USA.* Coherent Frequency Shift Keying (CFSK) protocols paired with a quantum receiver can significantly optimize power and bandwidth efficiency of communication channels. We present our preliminary experimental data obtained with the CFSK quantum communication testbed.

FM4D • Excitons in Condensed Matter Systems—Continued

FM4D.3 • 16:45
Strong Coupling between Quantum-confined Exciton Polaritons, Eric Martin[1,2], Jiaqi Hu[1], Zhaorong Wang[1], Hui Deng[1], Steven T. Cundiff[1]; *[1]Univ. of Michigan, USA; [2]Monstr Sense Technologies, USA.* We directly measure coupling between quantum confined exciton-polaritons and the relaxation channels from pumped exciton states into lasing polariton modes. Using double-quantum spectroscopy we demonstrate that interactions dominate the nonlinear signal of quantum confined polaritons.

FM4D.4 • 17:00
Observation of Trionic Optical Gain in Electrically Gated Two-Dimensional Molybdenum Ditelluride, Zhen Wang[1,2], Hao Sun[1,2], Qiyao Zhang[1,2], Jiabin Feng[1,2], Jianxing Zhang[1,2], Yongzhuo Li[1,2], Cun-Zheng Ning[1,2]; *[1]Dept. of Electronic Engineering, Tsinghua Univ., China; [2]International Center for Nano-Optoelectronics, Tsinghua Univ., China.* We report a new mechanism of optical gain originating from trions at extremely low-density levels in 2D material system by conducting systematic PL and reflectance spectroscopy on electrically-gated $MoTe_2$ mono- and bi-layer devices.

FM4D.5 • 17:15
Measurement and Reconstruction of The Entire Third-Order Exciton Polarization Using Multidimensional Spectroscopy, Travis Autry[1], Galan Moody[1], Corey McDonald[1], James M. Fraser[1,2], Richard P. Mirin[1], Kevin Silverman[1]; *[1]NIST, USA; [2]Physics, Queen's Univ., Canada.* We reconstruct the entire third order complex polarization of GaAs excitons using the amplitude and phase of all degenerate third-order wave mixing processes. All first and third order wave mixing processes are measured using multidimensional spectroscopy.

FM4D.6 • 17:30
Flexible Polaritons: Wannier Exciton-Plasmon Coupling in Metal-Semiconductor Structures, Jacob Khurgin[1]; *[1]Johns Hopkins Univ. , USA.* When Rabi energy exceeds the exciton binding energy a Wannier Exciton-Plasmon Polariton (WEPP) bound to the metal nanoparticle is formed. It is characterized by small excitonic radius and higher ionization energy that can exceed 100meV

Executive Ballroom 210E | Executive Ballroom 210F | Executive Ballroom 210G | Executive Ballroom 210H

CLEO: Science & Innovations

SM4E • High-Average Power Laser Systems—Continued

SM4E.3 • 16:45
Towards a Joule-Class Ultrafast Thin-Disk Based Amplifier at Kilohertz Repetition Rate, Clemens Herkommer[1,2], Peter Krötz[1], Sandro Klingebiel[1], Christoph Wandt[1], Dominik Bauer[3], Knut Michel[1], Reinhard Kienberger[2], Thomas Metzger[1]; [1]*TRUMPF Scientific Lasers GmbH & Co. KG, Germany;* [2]*Physik Dept., Technische Universität München, Germany;* [3]*TRUMPF Laser GmbH, Germany.* We report on the development of a thin-disk based multipass amplifier operating at 1 kHz repetition rate. The chirped pulse amplifier delivers 600mJ pulses before compression. A Joule-class laser source with sub-ps pulse durations is currently under construction using further amplifier stages.

SM4E.4 • 17:00 Invited
Laser Technologies for PW-Class Peak Power at Multi-kW Average Power, Thomas Spinka[1], David Alessi[1], Andrew J. Bayramian[1], Kyle Chesnut[2], Alvin Erlandson[1], Thomas Galvin[1], David Gibson[1], Brendan Reagan[1], Craig Siders[1], Emily F. Sistrunk[1], Constantin Haefner[1]; [1]*Lawrence Livermore National Lab, USA;* [2]*Physics and Astronomy, Univ. of California - Irvine, USA.* We will present multi-kW average power, PW-class peak power short pulse (≤150fs) high rep-rate (≥10Hz) laser designs based on Nd:glass and Tm:YLF, and explore progress on technologies that promise to enable or enhance their capabilities.

SM4E.5 • 17:30
Stabilization of Diffractive Beam Combining Using Pattern Recognition, Qiang Du[1], Tong Zhou[1], Lawrence Doolittle[1], Gang Huang[1], Russell Wilcox[1], Wim Leemans[1]; [1]*Lawrence Berkeley National Lab, USA.* A novel method of measuring and controlling phase errors in a 2D diffractive beam combiner is demonstrated. Output power is stabilized to <1% by controlling intensities of uncombined side beams.

SM4F • Precision Spectroscopy—Continued

SM4F.2 • 17:00
Frequency-comb-referenced phase spectroscopy measures plasmonic dynamics with picometre resolution, Anh D. Nguyen[1], Byung Jae Chun[1], Young-Jin Kim[1]; [1]*Nanyang Technological Univ. (NTU), Singapore.* A 1.94-Å dynamic motion of plasmonic nanohole array was measured with a 1.67 pm resolution using a frequency comb as the light source. This frequency-comb-referenced plasmonic phase spectroscopy could provide high speed, high resolution, and traceability to a time standard.

SM4F.3 • 17:15
Metamaterial infrared refractometer for detecting broadband complex refractive index of liquid material, Hibiki Kagami[1], Tomo Amemiya[1], Makoto Tanaka[1], Keisuke Masuda[1], Nobu Nishiyama[1], Shigehisa Arai[1]; [1]*Tokyo Inst. of Technology, Japan.* We developed a metamaterial refractometer for detecting broadband infrared complex refractive index of liquid materials. Using the device, the complex infrared refractive index of PMMA from 40 to 120 THz was measured for the first time.

SM4F.4 • 17:30
Real-time Reference for Frequency-shifted Fourier-transform Spectrometers using an Arbitrary-wavelength CW Reference Laser, Eric Martin[2,1], Christopher L. Smallwood[3,1], Torben L. Purz[1], Hanna G. Ruth[1], Steven T. Cundiff[1,2]; [1]*Univ. of Michigan, USA;* [2]*Monstr Sense Technologies, USA;* [3]*Dept. of Physics and Astronomy, San Jose State Univ., USA.* Frequency-shifted interferometers enable significant reduction of the measurement noise in Fourier-transform spectrometry and distance metrology. We demonstrate a real-time solution for referencing these interferometers with nanometer precision using an arbitrary-wavelength CW reference laser.

SM4G • Access & Radio Over Fiber—Continued

SM4G.4 • 16:45
Quasicoherent Receivers for Access Networks Using Fullwave Rectification Based Envelope Detection, Varghese A. Thomas[1], Siddharth Varughese[1], Stephen E. Ralph[1]; [1]*Georgia Inst. of Technology, USA.* We demonstrate a novel quasicoherent receiver architecture based on envelope detection employing fullwave rectification. Signaling rates of up to 18 GBaud (PAM-2) were experimentally achieved using low receiver bandwidths and low received powers.

SM4G.5 • 17:00
Polarization-insensitive Multipoint-to-point (MPTP) RoF Uplink for 5G Mobile Fronthaul, Jhih-Heng Yan[1], Sheng-Yang Lin[1], Hsu-Hong Huang[1], Kai-Ming Feng[1]; [1]*National Tsing Hua Univ., Taiwan.* A radio-over-fiber uplink system for 5G mobile fronthaul is experimentally demonstrated with a polarization insensitive optical modulation by reusing the polarization-orthogonal optical carriers from downlink. It's compatible with multipoint-to-point scenario by employing modified-STBC algorithm.

SM4H • Advanced Optical Technologies for Cells and Tissues—Continued

SM4H.3 • 16:45 Invited
Deciphering Bioengineered Tissues Functional Properties with Label-free Optical Techniques, Laura Marcu[1]; [1]*Univ. of California Davis, USA.* We present studies demonstrating fluorescence lifetime techniques as a means for monitoring the recellularization processes in vascular constructs grown in bioreactors and for assessing changes in bioengineered cartilage functional properties during matrix maturation.

SM4H.4 • 17:15
Determining Metabolic Changes Associated with Tamoxifen Treatment and Resistance in Breast Cancer, Jessica P. Houston[1], Kevin D. Houston[1], David Rodriguez[1], Yan Zheng[1]; [1]*New Mexico State Univ., USA.* Autofluorescence lifetimes of endogenous NAD(P)H are altered when breast cancer cells are treated with tamoxifen and is distinguishable when comparing tamoxifen sensitive and resistant breast cancer cells.

SM4H.5 • 17:30
Ultrasonically-Assisted In Situ 3D Optical Imaging And Manipulation: Challenges And Opportunities To Access Deep Tissue, Matteo Giuseppe Scopelliti[1], Yasin Karimi[1], Maysamreza Chamanzar[1]; [1]*Carnegie Mellon Univ., USA.* We demonstrate that that non-invasive ultrasound can be used to sculpt reconfigurable 3D optical patterns within tissue for light delivery (optical stimulation) and light collection (imaging) deep into the medium.

Meeting Room 211 A/B

CLEO: Applications & Technology

AM4I • Nanobiophotonics—Continued

AM4I.4 • 16:45
Tensorial Shear Stress Sensing Using Elliptically-Shaped Nanopillar Light-Emitting Diodes, Kunook Chung[1], Feng Tian[1], Jingyang Sui[1], Pei-cheng Ku[1]; *[1]Univ. of Michigan, USA.* We experimentally demonstrated a tensorial shear stress sensor capable of detecting both the magnitude and direction of the stress using an array of elliptically-shaped nanopillar GaN light-emitting diodes.

AM4I.5 • 17:00 Invited
Mapping Nanoscale Dynamics and Features Throughout Entire Mammalian Cells by 3D Single-Molecule Tracking and 3D Super-Resolution Imaging, Anna-Karin Gustavsson[1,2], Petar Petrov[1], Maurice Y. Lee[1,3], W. E. Moerner[1]; *[1]Dept. of Chemistry, Stanford Univ., USA; [2]Dept. of Biosciences and Nutrition, Karolinska Inst.t, Sweden; [3]Biophysics Program, Stanford Univ., USA.* We demonstrate an approach that combines point-spread function engineering with tilted light sheet illumination for 3D single-molecule tracking and 3D super-resolution imaging throughout entire mammalian cells.

AM4I.6 • 17:30
Comparison of Substrate-dependent SERS Chemical-enhancement Effects in Au and Ag for Compositional Analysis of Single-stranded DNA, Phuong H. Nguyen[1], Brandon Hong[1], Alexei Smolyaninov[1], Yeshaiahu Fainman[1]; *[1]Univ. of California San Diego, USA.* We experimentally observe and isolate chemical-enhancement effects in the Raman spectra of nucleotides on gold nanorod surfaces. We compare the enhanced spectra with similar enhancements observed on silver surfaces, and demonstrate their potential for DNA composition analysis.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM4J • Light Emission & Detection—Continued

SM4J.3 • 16:45
A hybrid nanowire photo-detector integrated in a silicon photonic crystal, Masato Takiguchi[1,2], Satoshi Sasaki[1], Kouta Tateno[1,2], Edward Chen[1], Kengo Nozaki[1,2], Sylvain Sergent[1,2], Eiichi Kuramochi[1,2], Guoqiang Zhang[1,2], Akihiko Shinya[1,2], Masaya Notomi[1,2]; *[1]NTT Basic Research Labs, Japan; [2]NTT Nanophotonics center, Japan.* We demonstrate hybridization of silicon photonic crystals with single nanowires to create on-chip photo-detectors. The measured photocurrent is enhanced by the photonic crystal optical antenna.

SM4J.4 • 17:00
Vertically Stacked Silicon Nanowire Photodetectors for Spectral Reconstruction, Jiajun Meng[1], Jasper Cadusch[1], Kenneth Crozier[1,2]; *[1]Dept. of Electrical and Electronic Engineering, Univ. of Melbourne, Australia; [2]School of Physics, Univ. of Melbourne, Australia.* We experimentally demonstrate the use of vertically stacked silicon nanowire photodetectors for computational spectral reconstruction at visible wavelengths. The method is based on the photodetectors having tailored responsivity spectra, achieved by standard nanofabrication processes.

SM4J.5 • 17:15
Spectrally selective detection with In_2O_3/n-Si radial heterojunction nanowire photodiodes, Han-Don Um[1], Amit Solanki[1], Ashwin Jayaraman[2], Roy G. Gordon[1,2], Fawwaz Habbal[1]; *[1]John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Dept. of Chemistry and Chemical Biology, Harvard Univ., USA.* We demonstrated radial heterojunction nanowire photodiodes consisting of an In_2O_3-shell/Si-core structure using conformal coating of an In_2O_3 layer on n-Si nanowires. We achieve selective spectral response from 400 to 700 nm by tuning the nanowire diameter.

SM4J.6 • 17:30
Tuning Lasing Emission towards Long Wavelengths in GaAs-(In,Al)GaAs Core-Multishell Nanowires, Thomas Stettner[1], Paul J. Schmiedeke[1], Andreas Thurn[1], Markus Döblinger[2], Jochen Bissinger[1], Sonja Matich[1], Daniel Ruhstorfer[1], Hubert Riedl[1], Jonathan J. Finley[1], Gregor Koblmueller[1]; *[1]Walter Schottky Institut and Physics Dept., Technical Univ. of Munich, Germany; [2]Dept. of Chemistry, Ludwig-Maximilians-Universität München, Germany.* We demonstrate lasing from GaAs-InGaAs-based core-multiple quantum well nanowires with lasing emission tunable from ~0.8 to ~1.1µm. By controlling the shell growth temperature, the quantum well In-molar fraction is increased to 25% without plastic relaxation.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM4K • A&T Topical Review on Flat Optics II—Continued

AM4K.3 • 17:00
Inverse-Designed Spectrum Splitters for Color Imaging, Philip Camayd-Muñoz[1], Gregory D. Roberts[1], Max Debbas[1], Conner Ballew[1], Andrei Faraon[1]; *[1]Caltech, USA.* Absorptive filters provide color discrimination in image sensors by eliminating 70% of incident light. Instead, we present a dielectric scatterer that efficiently sorts light based on color. This may improve the sensitivity and functionality of detectors.

AM4K.4 • 17:15 Invited
Generating High Performance, Topologically-complex Metasurfaces with Neural Networks, Jonathan A. Fan[1]; *[1]Electrical Engineering, Stanford Univ., USA.* We show that generative neural networks, combined with topology optimization, are a computationally efficient route to producing high efficiency, topologically-complex metasurfaces across a broad operating parameter space.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM4L • Specialty Fibers—Continued

SM4L.3 • 16:45
Gain dependent mode analysis of large mode area fiber with confined Ytterbium doping, Stefan Gausmann[1], Jose Enrique Antonio-Lopez[1], James Anderson[1], Steffen Wittek[1], Rodrigo Amezcua Correa[1], Axel Schülzgen[1]; *[1]Univ. of Central Florida - CREOL, USA.* We quantify for the first time higher-order-mode content as a function of gain in large-mode-area fiber with confined Yb-doping using spatially and spectrally resolved imaging. Our results clearly indicate higher-order-mode suppression due to differential gain.

SM4L.4 • 17:00
Influence of sapphire sol-gel cladding on Tm:YAG single crystal fiber laser operation, Ben Eshel[1,2], Gisele Maxwell[3], Carl Liebig[2], Kent L. Averett[2], Sean A. McDaniel[2], Gary Cook[2]; *[1]Azimuth Corporation, USA; [2]Air Force Research Labs, USA; [3]Shasta Crystals, USA.* A sapphire sol-gel cladding (0–5 deposition cycles) was observed to increase the slope efficiency of a 2% Tm-doped single-crystal YAG fiber laser from 16% to 43.5% with respect to transmitted power and reduce the Rayleigh scattering.

SM4L.5 • 17:15
Precise characterization of rare-earth doped fibers for laser cooling using a non-contact method, Mostafa Peysokhan[1], Esmaeil Mobini[1], Arman Allahverdi[1], Behnam Abaie[1], Arash Mafi[1]; *[1]Univ. of New Mexico , USA.* A non-contact, non-destructive method is presented for measuring the external quantum efficiency, background absorption, and resonance absorption of a Ytterbium-doped ZBLAN fiber. The precise values of these parameters are essential for optical refrigeration in fibers.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

FM4M • Solid State High Harmonic Generation—Continued

FM4M.4 • 17:00
Symmetry and Polarization of High-Order Harmonic Generation from Solids, Shima Gholam Mirzaeimoghadar[1], Shicheng Jiang[3], Erin Crites[1], John E. Beetar[1], Ruifeng Lu[3], Chii-Dong Lin[2], Michael Chini[1,4]; [1]*Dept. of Physics, Univ. of Central Florida, USA;* [2]*J. R. Macdonald Lab, Dept. of Physics, Kansas State Univ., USA;* [3]*Dept. of Applied Physics, Nanjing Univ. of Science and Technology, China;* [4]*College of Optics and Photonics, Univ. of Central Florida, USA.* We study the polarization states of high-order harmonics emitted from a-cut ZnO crystals driven by femtosecond mid-infrared laser pulses. The polarization states of even and odd harmonics are sensitive to structural symmetries of the crystal.

FM4M.5 • 17:15
Topological strong field physics on sub-laser cycle timescale, Alvaro Jimenez-Galan[1], Rui Silva[1,2], Bruno Amorim[3], Olga Smirnova[1,4], Misha Ivanov[1,5]; [1]*Max Born Institut, Germany;* [2]*Departamento de Fisica Teorica de la Materia Condensada, Universidad Autonoma de Madrid, Spain;* [3]*CeFEMA, Instituto Superior Técnico, Universidade de Lisboa, Portugal;* [4]*Technische Universität Berlin, Germany;* [5]*Blackett Lab, Imperial College London, UK.* Topological state is linked with dynamics, as manifested via chiral-edge currents. But is there an inherent timescale, associated with topology? We address this question using unique properties of primary electronic response to strong optical fields.

FM4M.6 • 17:30
High-Harmonic Generation from Topological Insulators, Denitsa Baykusheva[1], Jian Lu[1], Jonathan A. Sobota[2], Hadas Soifer[2], Costel R. Rotundu[2], Patrick S. Kirchmann[2], David A. Reis[1], Shambhu Ghimire[1]; [1]*Stanford PULSE Inst., USA;* [2]*Stanford Inst. for Materials and Energy Sciences, USA.* We report the observation of efficient high-harmonic generation in the three-dimensional topological insulators Bi_2Se_3 and Bi_2Te_3 driven by mid-infrared laser pulses of peak intensities ~10^{12} W/cm^2.

Marriott
Salon III

CLEO: Science & Innovations

SM4N • Surface Emitting Lasers—Continued

SM4N.3 • 16:45
Lateral Integration of VCSEL and Amplifier with Resonant Wavelength Detuning Design, Shanting Hu[1], Masashi Takanohashi[1], Xiaodong Gu[1], Keisuke Shimura[1], Fumio Koyama[1]; [1]*Tokyo Inst. of Technology, Japan.* We propose and demonstrate the lateral integration of VCSEL and slow-light waveguide amplifier with in-plane resonant wavelength detuning design, enabling the unidirectional coupling. A record quasi-single-mode power (>27mW) with narrow beam divergence (<0.06°) is presented.

SM4N.4 • 17:00
Compact Dot Projector based on Folded Path VCSEL Amplifier for Structured Light Sensing, Mizuki Morinaga[1], Xiaodong Gu[1], Keisuke Shimura[1], Akihiro Matsutani[1], Fumio Koyama[1]; [1]*Tokyo Inst. of Technology, Japan.* We demonstrate a VCSEL amplifier with folded-path waveguide layout and cylindrical lens array for the dot projection. We obtained >5,000 dots in a viewing angle of 12° x 15° for 0.4 mm^2 chip size.

SM4N.5 • 17:15
Two-Dimensional Coupling in Tuned Coherent Hexagonal Vertical Cavity Laser Arrays, Bradley J. Thompson[1], Katherine Lakomy[1], Kent D. Choquette[1]; [1]*Univ. of Illinois, USA.* A 6-element hexagonal VCSEL array is resonantly tuned to coherence. The far-field profile is narrowed in two-dimensions, with a FWHM of 2° compared to a single-emitter with 10° FWHM.

SM4N.6 • 17:30
Optimum optical frequency comb generation via externally injection of a gain switched VCSEL, Mohab N. Hammad[1], Eamonn Martin[1], Prajwal Doddaballapura Lakshmijayasimh[1], Aleksandra Kaszubowska-Anandarajah[2], Pascal Landais[1], Prince M. Anandarajah[1]; [1]*Dublin City Univ., Ireland;* [2]*Connect, Trinity College Dublin, Ireland.* A gain-switched VCSEL is subjected to external optical injection to enable optimized comb generation. The generated comb at 6.25GHz portrays a carrier-to-noise-ratio of 55dB, optical linewidth of 15kHz and a RIN of ~130dB/Hz.

Marriott
Salon IV

SM4O • Nonlinear Phonon Interactions—Continued

SM4O.4 • 16:45
Broadband Brillouin-based phase shifter with phase amplification in a silicon waveguide, Luke Mckay[1], Moritz Merklein[1], Alvaro Casas-Bedoya[1], Amol Choudhary[1], Yang Liu[1], Micah Jenkins[2], Charles Middleton[2], Alex Cramer[2], Joseph Devenport[2], Anthony Klee[2], Richard DeSalvo[2], Benjamin J. Eggleton[1]; [1]*The Univ. of Sydney, Australia;* [2]*Harris Corporation, USA.* We propose and demonstrate a broadband silicon phase shifter based on Brillouin scattering. We have achieved a 360° phase shift over a 15 GHz bandwidth with a phase amplification factor of 25.7 using only 1.5 dB gain.

SM4O.5 • 17:00
High-resolution RF spectrum analyzer on a chip, Eric Magi[1], Alvaro Casas-Bedoya[1], Moritz Merklein[1], Amol Choudhary[1], Duk-yong Choi[2], Pan Ma[2], Khu Vu[2], Stephen Madden[2], Robert L. Nelson[3], Weimin Zhou[4], Benjamin J. Eggleton[1]; [1]*Univ. of Sydney, Australia;* [2]*Australian National Univ., Laser Physics Centrer, Australia;* [3]*Air Force Research Lab at Wright Patterson,, USA;* [4]*US Army Research Lab, USA.* We demonstrate a high-resolution microwave spectrum analyzer enabled by an on-chip stimulated Brillouin scattering based tunable bandpass filter configuration. 30 MHz spectral resolution of single and multi-tone RF frequencies up to 12 GHz are demonstrated.

SM4O.6 • 17:15
Suppression of Stimulated Raman Scattering in a Two-Color Three-Beam Setup, Thomas Würthwein[1], Niels Irwin[1], Carsten Fallnich[1,2]; [1]*Inst. of Applied Physics, Germany;* [2]*MESA+ Inst. of Nanotechnology, Netherlands.* We present a technique for the suppression of stimulated Raman scattering using probe depletion in a two-color three-beam setup toward label-free sub-diffraction-limited imaging. A Raman suppression up to 79% could be shown.

SM4O.7 • 17:30 Invited
Brillouin Microscopy for 3D Biomechanical Imaging, Irina Kabakova[1]; [1]*Univ. of Technology Sydney, Australia.* Brillouin microscopy is a non-contact and marker-free technique for probing viscoelasticity of tissues and cells in 3D. Here I review the principles of Brillouin microscopy, latest breakthroughs and applications to cell mechanobiology and disease diagnostics.

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FM4A • Quantum Nanophotonics II: Diamond & Boron Nitride—Continued

FM4B • Topological Photonics II—Continued

FM4B.8 • 17:45
Observation of corner states in topological photonic crystal slabs, Xiaodong Chen[1], Wei-Min Deng[1], Fu-Long Shi[1], Jian-Wen Dong[1]; [1]*Sun Yat-Sen Univ., China*. With the near-field scanning measurement, we show the observation of in-gap corner states in topological photonic crystal slabs which consist of periodic dielectric rods on a perfect electric conductor.

FM4C • New Systems for Quantum Communications—Continued

FM4C.8 • 17:45
Symmetrical Clock Synchronization with Time-Correlated Photon Pairs, Jianwei Lee[1], Lijiong Shen[1,2], Alessandro Cerè[1], James Troupe[3], Antia Lamas-Linares[4], Christian Kurtsiefer[1,2]; [1]*Centre for Quantum Technologies, Singapore;* [2]*Physics, National Univ. of Singapore, Singapore;* [3]*Applied Research Labs, USA;* [4]*Texas Advanced Computing Center, USA*. We demonstrate a distance-independent clock synchronization protocol, using counter-propagating photons from spontaneous parametric down-conversion pair sources, secure against symmetric-delay attacks. With rates of 200 coincidences/s, we record a precision of 51ps over 100s.

FM4D • Excitons in Condensed Matter Systems—Continued

FM4D.7 • 17:45
Gate-tunable terahertz emission at oxide interfaces via ultrafast spin-to-charge current conversion, Qi Zhang[1], Deshun Hong[1], Changjiang Liu[1], Richard Schaller[1], Dillon Fong[1], Anand Bhattacharya[1], Haidan Wen[1]; [1]*Argonne National Lab, USA*. We demonstrate gate-tunable spintronic terahertz (THz) emission at the interface of $LaAlO_3$ / $SrTiO_3$ due to ultrafast spin-to-charge current conversion. The soft phonon mode of $SrTiO_3$ is also observed in the emitted THz spectra.

17:30–18:30 Diversity and Inclusion Reception, *Winchester Room, Hilton San Jose*

18:30–20:00 Lasers for Attosecond 2.0, *Room 230A*

18:30–20:00 *NEW* Workshop 2: Will Quantum Computing Actually Work?, *Room 210A*
***NEW* Workshop 3: What Will be the Largest Commercial Application for Optical Freqency Combs in 10 Years?,** *Room 210B*

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H

CLEO: Science & Innovations

SM4E • High-Average Power Laser Systems—Continued

SM4E.6 • 17:45
Deep Learning for Real-Time Modeling of High Repetition Rate, Short Pulse CPA Laser Amplifier, Sandrine I. Herriot[1], Thomas Galvin[1], Brenda Ng[1], Emily Sistrunk Link[1], Shawn Betts[3], Craig Siders[1], Thomas Spinka[1], Daniel Smith[1], Sachin Talathi[2], Wade Williams[1], Constantin Haefner[1]; [1]*LLNL, USA;* [2]*Unknown, USA;* [3]*UC Irvine, USA.* Real-time feedback loop of kHz repetition rate, high intensity laser sets new challenges to the traditional modeling concept. We present a deep learning approach to model amplification and laser-induced damage in CPA laser system enabling high speed analysis above tens of kHz.

SM4F • Precision Spectroscopy—Continued

SM4F.5 • 17:45
Calibration-free Wavelength Measurement with Sub-femtometer Resolution Based on All-fiber Rayleigh Speckles, Wang Shuai[1], Zhaopeng Zhang[1], Xinyu Fan[1], Bin Wang[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China.* We propose an ultra-high resolution wavelength measurement approach with all-fiber based system. By extracting the Rayleigh speckles of a single mode fiber, we achieve a spectral resolution of 0.3 fm in optical frequency measurement.

SM4G • Access & Radio Over Fiber—Continued

SM4H • Advanced Optical Technologies for Cells and Tissues—Continued

SM4H.6 • 17:45
Nanophotonic Neural Probes for *in vivo* Light Sheet Imaging, Wesley D. Sacher[1], Xinyu Liu[1], Ilan Felts Almog[2], Anton Fomenko[4], Thomas Lordello[2], Fu-Der Chen[2], Homeira Moradi-Chameh[4], Azadeh Naderian[4], Michael Chang[4], Trevor Fowler[1], Taufik Valiante[4,5], Andres M. Lozano[4,5], Laurent Moreaux[1], Joyce K. Poon[2,3], Michael L. Roukes[1]; [1]*Division of Physics, Mathematics, and Astronomy, California Inst. of Technology, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [3]*Max Planck Inst. for Microstructure Physics, Germany;* [4]*Krembil Research Inst., Canada;* [5]*Division of Neurosurgery, Dept. of Surgery, Toronto Western Hospital, Univ. of Toronto, Canada.* We present implantable silicon neural probes with nanophotonic waveguide routing networks and grating emitters for light sheet imaging. Fluorescein beam profiles, fluorescent bead imaging, and fluorescence brain imaging *in vivo* are presented.

17:30–18:30 Diversity and Inclusion Reception, *Winchester Room, Hilton San Jose*

18:30–20:00 Lasers for Attosecond 2.0, *Room 230A*

18:30–20:00 ***NEW*** **Workshop 2: Will Quantum Computing Actually Work?,** *Room 210A*
NEW **Workshop 3: What Will be the Largest Commercial Application for Optical Freqency Combs in 10 Years?,** *Room 210B*

Meeting Room 211 A/B

CLEO: Applications & Technology

AM4I • Nanobiophotonics—Continued

AM4I.7 • 17:45
Point-of-Care Multiplexing Assay for Dengue Using Barcoded Fluorescent Microspheres, Ryan X. Yuan[1], Srishti Garg[1], Anupriya Gopalsamy[2], Frederic Fellouse[2], Sachdev Sidhu[2], James Dou[3], J. Stewart Aitchison[1]; [1]*Dept. of Electrical & Computer Engineering, Univ. of Toronto, Canada;* [2]*Banting and Best Dept. of Medical Research and Dept. of Medical Genetics, Univ. of Toronto, Canada;* [3]*ChipCare, Canada.* Chromatic dispersion is utilized to separate fluorescent signals in different fluorescent dyes. The fluorescence intensity of allophycocyanin is used as the barcode fluorophore for specific biomarkers, enabling a four-plex biomarker detection.

Meeting Room 211 C/D

CLEO: Science & Innovations

SM4J • Light Emission & Detection—Continued

SM4J.7 • 17:45
50 Gb/s PAM4 Low-Voltage Si-Ge Avalanche Photodiode, Binhao Wang[1], Zhihong Huang[1], Xiaoge Zeng[1], Di Liang[1], Marco Fiorentino[1], Wayne Sorin[1], Raymond Beausoleil[1]; [1]*Hewlett Packard Enterprise, USA.* We demonstrate a 50 Gb/s PAM4 operation of an integrated Si-Ge APD with low breakdown voltage of -10 V. The receiver has achieved -17 dBm optical input power at 50 Gb/s PAM4 with a bit error rate of 2.4×10^{-4}.

Meeting Room 212 A/B

CLEO: Applications & Technology

AM4K • A&T Topical Review on Flat Optics II—Continued

AM4K.5 • 17:45
Programmable metamaterials & metasurfaces for ultra- compact multi-functional photonics, Apratim Majumder[1], Sourangsu Banerji[1], Kazumasa Miyagawa[1], Monjurul Meem[1], Mark Mondol[2], Berardi Sensale Rodriguez[1], Rajesh Menon[1]; [1]*Univ. of Utah, USA;* [2]*MIT, USA.* We demonstrate the design and experimental verification of several examples of programmable metamaterials and metasurfaces. Such devices offer the advantage of high-density integration and versatility.

Meeting Room 212 C/D

CLEO: Science & Innovations

SM4L • Specialty Fibers—Continued

17:30–18:30 Diversity and Inclusion Reception, *Winchester Room, Hilton San Jose*

18:30–20:00 Lasers for Attosecond 2.0, *Room 230A*

18:30–20:00 ***NEW*** **Workshop 2: Will Quantum Computing Actually Work?,** *Room 210A*
NEW **Workshop 3: What Will be the Largest Commercial Application for Optical Freqency Combs in 10 Years?,** *Room 210B*

Marriott Salon I & II	Marriott Salon III	Marriott Salon IV

CLEO: QELS-Fundamental Science

FM4M • Solid State High Harmonic Generation—Continued

FM4M.7 • 17:45
Enhancement of Harmonic Generation in Gases Using an All-Dielectric Metasurface, Jared S. Ginsberg[1], Adam C. Overvig[1], M. M. Jadidi[1], Stephanie Malek[1], Gauri Patwardhan[1,2], Nicolas Swenson[2], Nanfang Yu[1], Alexander Gaeta[1]; [1]*Applied Physics and Applied Mathematics, Columbia Univ., USA;* [2]*Applied and Engineering Physics, Cornell Univ., USA.* We design and fabricate a dielectric metasurface for enhancing harmonic generation from gases with mid-infrared pulses. We observe third-harmonic generation in Ar at pump intensities as low as 1.8×10^{12}W/cm^2.

CLEO: Science & Innovations

SM4N • Surface Emitting Lasers—Continued

SM4N.7 • 17:45
Energy-Efficient VCSELs for 200+ Gb/s Optical Interconnects, Gunter Larisch[1], Ricardo Rosales[2], James A. Lott[2], Dieter Bimberg[2,1]; [1]*Bimberg Chinese-German Center for Green, China;* [2]*Technische Universität Berlin, Germany.* Vertical-cavity surface-emitting lasers for 200+ Gbit/s single fiber data transmission systems emitting at 850 nm, 880 nm, 910 nm, and 940 nm are presented showing a heat-to-bit-rate energy efficiency of 240 fJ/bit.

SM4O • Nonlinear Phonon Interactions—Continued

17:30–18:30 **Diversity and Inclusion Reception,** *Winchester Room, Hilton San Jose*

18:30–20:00 **Lasers for Attosecond 2.0,** *Room 230A*

18:30–20:00 *NEW* **Workshop 2: Will Quantum Computing Actually Work?,** *Room 210A*
NEW **Workshop 3: What Will be the Largest Commercial Application for Optical Freqency Combs in 10 Years?,** *Room 210B*

07:00–18:30 Registration, *Concourse Level*

08:00–10:00 JTu1A • Joint Plenary Session, *Grand Ballroom 220A*

10:00–17:00 Exhibit Open (10:00–17:00), Coffee Break (10:00–11:30), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

10:30–12:00 Quantum Information Science and Technology Initiatives, *Exhibit Hall Theater I*

10:30–13:30 SC455: Integrated Photonics for Quantum Information Science and Technology (Dirk Englund, *MIT, USA***)**

10:30–14:30 SC403: NanoCavity Quantum Electrodynamics and Applications (Jelena Vuckovic, *Stanford University, USA***)**
SC410: Finite Element Modeling Methods for Photonics and Optics (Arti Agrawal, *City University, UK*
SC438: Photonic Metamaterials (Nader Engheta, *University of Pennsylvania, USA***)**
SC424: Optical Terahertz Science and Technology (David G. Cooke, *McGill University, Canada***)**

12:00–13:30 OIDA VIP Industry Leaders Speed Meeting Event, *Booth 2605*, Sponsored by GoFoton

Exhibit Halls 1-3

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.1
Response of Porcine Articular Cartilage to Irradiation by an Ultrafast, Burst-Mode Laser, Thomas W. Dzelzainis[6], Sabrina Hammouti[6], Robin Marjoribanks[6], Lothar Lilge[7,2], Margarete Akens[1,7], Omer Ilday[3], Hamit Kaylaycioglu[3], Seydi Yavas[4,5], Sohret Karamuk[5], Melissa Prickaerts[1,7], Kailas Cassidy[1], Ahmad Golaraei[6,2], Virginijus Barzda[6,8]; [1]*Techna Inst., Univ. Health Network, Canada;* [2]*Princess Margaret Cancer Centre, Univ. Health Network, Canada;* [3]*Bilkent Univ., Turkey;* [4]*Physics, Bogazici Univ., Turkey;* [5]*Lumos Laser, Turkey;* [6]*Physics, Univ. Of Toronto, Canada;* [7]*Medical Biophysics, Univ. of Toronto, Canada;* [8]*Chemical ad Physical Sciences, Univ. of Toronto Mississauga, Canada.* Plasma-mediated ablation by ultrafast pulses is generally considered to be a material-independent process. We show that, in certain circumstances, this assumption may be invalid. Physical processes involved and the impact on applications are discussed.

JTu2A.2
Ultra-short Laser Texturing of Biomimetic Hybrid Thin film Coatings from Natural Polymers and Their Ceramic Composites for Cellular Guidance, Albena Daskalova[1], Irina Bliznakova[1], Anton Trifonov[2], Liliya Angelova[1], Heidi Deqlercq[3], Ivan Buchvarov[2]; [1]*Inst. of Electronics-BAS, Bulgaria;* [2]*Faculty of Physics, St. Kliment Ohridski Univ. of Sofia,, Bulgaria;* [3]*Dept. of Basic Medical Sciences, Ghent Univ., Belgium.* The goal of this study was to combine the osteogenic properties of biopolymers with good mechanical properties of ceramics to design improved implant interface and investigate the effect of fs laser texturing on surface characteristics of chitosan (CH) /Hydroxyapatite (HAp)/ ZrO_2 composite biofilms.

JTu2A.3
Multivariate Machine Learning Approaches for Data Fusion: Behavioral and Neuroimaging (Functional Near Infra-Red Spectroscopy) Datasets, Amir H. Gandjbakhche[1], Hadis Dashtestani[1]; [1]*National Inst.s of Health, USA.* Coupling behavioral with neuroimaging datasets promises to provide insight into medical data analyses. Here, we investigate the relation between psychopathic traits and brain activities captured by functional near infra-red spectroscopy during a moral judgment task.

JTu2A.4
Multifocal Compressive Sensing Spectral Domain Optical Coherence Tomography Based on Bessel Beam, Luying Yi[1], Liqun Sun[1]; [1]*Tsinghua Univ., China.* We present a method CS-MB-SDOCT, which combines multifocal Bessel beam spectral-domain optical coherence tomography (MB-SDOCT) and compressive sensing (CS) to increase the imaging depth using a spectrometer with lower spectral resolution.

JTu2A.5
An Absorbance Spectrum Estimation-based Accurate Colorization Method for Holographic Imaging of Pathology Slides, Tairan Liu[1], Yibo Zhang[1], Yujia Huang[1], Da Teng[1], Yinxu Bian[1], Yichen Wu[1], Yair Rivenson[1], Alborz Feizi[1], Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* We present an accurate-color holographic imaging method for pathology slide samples based on absorbance spectrum estimation of histochemical stains, which improves the color accuracy and reduces the required number of illumination wavelengths.

JTu2A.6
Corneal imaging with extended imaging range using dual spectrometer high-resolution SD-OCT, Lulu Wang[1]; [1]*NTU, Singapore.* A dual-spectrometer SD-OCT system with extended imaging range, high spatial resolution was demonstrated for pig corneal imaging *ex vivo*. Spectra from the two spectrometers are combined to achieve a 3.4 mm maximum depth range with an axial and lateral resolution of 1.86 μm(n=1.38) and 1.96 μm.

JTu2A.7
Generation of surface plasmonic resonance mode on highly ordered diverse conformation of Au nanostructures, Hyerin Song[1], Heesang Ahn[1], Seunghun Lee[1], Tae Young Kang[1], Soojung Kim[1], Taeyeon Kim[1], Kyujung Kim[1]; [1]*Pusan National Univ., South Korea (the Republic of).* Three different shapes of Au nanostructures, which are cone, embossed, and wave-like shapes, were fabricated with a high order based on an anodized aluminum oxide (AAO) template and utilized for surface-enhanced Raman scattering system.

JTu2A.8
Improving the Temporal Resolution of Speckle based Remote Phonocardiogram Sensing via Laser Modulation, Nisan Ozana[1], Zeev Markman[2], Ran Califa[2], Zeev Zalevsky[1]; [1]*Bar Ilan Univ., Israel;* [2]*Continuse Biometrics, Israel.* We present a method for remote phonocardiogram sensing which employs temporal modulation of the illumination laser. This method yields a significant enhancement of the temporal bandwidth of the captured speckle image sequence, thus improving performance.

JTu2A.9
Smart Carbon Fiber Sensing Systems Applied to Biomechanics, José R. Galvão[1], Talita Bastos[1], Carlos Zamarreño[2], John Canning[3], Cicero Martelli[1], Jean Carlos Cardozo da Silva[1]; [1]*Federal Univ. of Technology – Pr, Brazil;* [2]*Univ. of Navarra, Pamplona, Spain;* [3]*Univ. of Technology Sydney, Australia.* This paper presents three applications of carbon fiber reinforced polymer with integrated FBG sensor systems in biomechanics. In vivo tests were performed showing that the sensors are robust for the different applications.

JTu2A.10
Color imaging through the scattering media, Lei Zhu[1], Yuxiang Yuxiang[1], Jietao Liu[1], Xiaopeng Shao[1]; [1]*Xidian Univ., China.* We developed a method to realize color imaging through the scattering media based on triple correlation technique. This method enables color imaging through the scattering media without the wavefront shaping technique and deconvolution technique.

JTu2A.11
Flat-top Supercontinuum Generation Based on Electro-optic Optical Frequency Comb, Minje Song[2,1], Sang-Pil Han[2], Sungil Kim[2], Minhyup Song[2]; [1]*Kyungpook National Univ., South Korea (the Republic of);* [2]*Electronics and Telecommunications Research Inst., South Korea (the Republic of).* We demonstrate the optical frequency comb based supercontinuum (OFC-SC) with flatness using the pulse shaping technique and the dispersion compensation. Furthermore, we achieve the short pulse width with electro-optic OFC-SC.

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.12
In-situ laser fabrication to reduce eccentricity errors in optical encoders, Robin Hahn[1], Christof Pruss[1], Martina Dombrowski[1], Maik Gerngross[2], Matthias Schirmer[2], Christian Kreisel[3], Bernd Sommer[4], David Hopp[5], Christina Schneider[5], Christian Sellmer[5], Mathias Wenzler[5], Wolfgang Osten[1]; *[1]Inst. of Applied Optics, Germany; [2]Allresist GmbH, Germany; [3]Acsys Lasertechnik GmbH, Germany; [4]Stvision GmbH, Germany; [5]Sick Stegmann GmbH, Germany.* Rotational encoders are of high importance of nowadays robotic systems. We present a technique for laser based post assembly fabrication, increasing the accuracy, decreasing the alignment effort and giving the possibility of an increased flexibility.

JTu2A.13
Withdrawn

JTu2A.14
A depth information acquisition method through 3D polarization imaging technology, Xuan Li[1], Fei Liu[1], Fangyi Chen[1], Yudong Cai[1], Xiaopeng Shao[1]; *[1]Xidian Univ., China.* We propose a method to get the real depth information of the object based on the spatial coordinate transformation method in 3D polarization imaging. This technique is useful for 3D polarization imaging of single camera.

JTu2A.15
Investigation of Surface Treatment Methods for 3D Printed Optical Components, Joshua Davidson[1], Jianan Zhang[1], Tim Kane[1], Ram Narayanan[1]; *[1]Penn State Univ., USA.* This paper proposes a method for preparing 3D printed surfaces as commercial quality optical components. Utilizing Formlabs' dipping method and pulse-reverse electroplating, a surface finish of λ/10 can be achieved.

JTu2A.16
Well Arranged PDLC Droplets in Grating Structures Inducing the Reduction of Driving Voltage, Chiu-Chang Huang[1], Hsuan-Han Huang[1], Bor-Wei Liang[1], Cheng-Che Lee[1], Bo-Han Kung[1], Chieh-Hsiung Kuan[1]; *[1]National Taiwan Univ., Taiwan.* Grating structures were integrated in the polymer dispersed liquid crystal (PDLC) device and induced the arrangement of PDLC droplets which haven't been reported. In addition, the driving voltage was reduced.

JTu2A.17
Optical Engineering of Vector Beams with Parabolic and Elliptic Cross-Sections, Sergejus Orlovas[1], Pavel Gotovski[1], Justas Baltrukonis[1], Vytautas Jukna[1], Titas Gertus[1]; *[1]National Center for Physical Sciences an, Lithuania.* Beam profile engineering is a promising approach in various applications. We introduce vector versions of Mathieu and Weber beams and use those vector beams to engineer controllable spatial phase and amplitude distributions with polarization control.

JTu2A.18
Charging of a Single InAs QD with Electrically-Injected Holes using a Lateral Electric Field, Xiangyu Ma[1], Yuejing Wang[1], Joshua Zide[1], Matthew Doty[1]; *[1]Univ. of Delaware, USA.* We design and fabricate a 3-electrode device that applies 2-D electric fields to a single InAs QD. We observe electrical injection of holes into a QD due to the lateral electric field component.

JTu2A.19
Interaction of an Atomic Gas with Light Carrying Orbital Angular Momentum, Guillermo Quinteiro[1], Patricio Grinberg[1], Christian T. Schmiegelow[1]; *[1]Universidad de Buenos Aires, Argentina.* The orbital angular momentum of light affects the response of point-like and extended systems. For a gas undergoing S-P transitions we show qualitative differences among collimated and tightly-focused light without and with orbital angular momentum.

JTu2A.20
Highly efficient optical pumping of Rb atoms for evanescent fields at dielectric-vapor interfaces, Eliran Talker[3], P. Arora[3], Yefim Barash[3], David Wilkowski[1,2], Uriel Levy[3]; *[1]School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore, Singapore; [2]MajuLab, CNRS-UCA-SU-NUS-NTU International Joint Research Unit, Singapore, Singapore; [3]Dept. of Applied Physics, The Hebrew Univ., Givat Ram Campus, Israel.* Optical prism integrated with a vapor cell and excited by evanescent wave under total internal reflection is used to study nanoscale light-atom interactions and to demonstrate efficient optical pumping of rubidium at a dielectric-vapor interface.

JTu2A.21
Single photon spectroscopy of excited state structure in hBN quantum emitters, Matthew Feldman[1,2], Claire Marvinney[1], Alex Puretzky[1], Philip Evans[1], Richard F. Haglund[2], Benjamin Lawrie[1]; *[1]Oak Ridge National Lab, USA; [2]Vanderbilt Univ., USA.* The electronic structure of hBN defects remains poorly defined despite its importance for room-temperature single-photon sources. We address this deficiency by characterizing shelving dynamics and photon correlations between photochemically modified electronic transitions.

JTu2A.22
Trapped ion slow light: first photonic interaction between a photon from an ion and neutral atoms, John M. Hannegan[1,2], James Siverns[1,2], Qudsia Quraishi[3,1]; *[1]Joint Quantum Inst., USA; [2]Inst. for Research in Electronics and Applied Physics, USA; [3]US Army Research Lab, USA.* Hybrid quantum systems will enable practical implementation of quantum-memory based photonic networking. Using quantum frequency conversion, we slow photons emitted from 138Ba+ using warm 87Rb vapor, demonstrating the first hybrid interaction between ion-emitted photons and neutral atoms.

JTu2A.23
Measurements of Frequency-Resolved Third-Order Correlations in Quantum Dot Resonance Fluorescence, Yamil A. Nieves[1], Andreas Muller[1]; *[1]Univ. of South Florida, USA.* We investigated the three-photon spectrum of quantum dot resonance fluorescence, revealing significantly more pronounced photon antibunching at the Mollow triplet sidebands and more strongly correlated emission through virtual states than at second order.

JTu2A.24
Upper Bound on the Duration of Quantum Jumps, Mathias A. Seidler[1], Alessandro Cere[1], Ricardo Gutierrez-Jauregui[2], Roc'io Jauregui[3], Christian Kurtsiefer[1]; *[1]National Univ. of Singapore, Singapore; [2]Instituto de Fisica, UNAM, Mexico; [3]Inst. for Quantum Science and Engineering, Texas A&M Univ., USA.* We estimate the time scale of quantum jumps from the time correlation of photon pairs generated from a cascade decay in a cold cloud of ^{87}Rb. We find an upper bound of 21±11 ps.

JTu2A.25
Experimental observation of multi-atom Dicke states in an atomic vapor using optical 2D coherent spectroscopy, Shaogang Yu[2,1], Michael Titze[2], Yifu Zhu[2], Xiaojun Liu[1], Hebin Li[2]; *[1]Wuhan Inst. of Physics & Mathematics, China; [2]Florida International Univ., USA.* We report the first observation of two-, three-, four-, five-, six-, and seven-atom Dicke states in an atomic vapor using optical multi-quantum 2D coherent spectroscopy. This has significant implications in the studies of many-body physics.

JTu2A.26
Characterization of the Superhyperfine Interaction in ^{171}Yb:YVO$_4$, Yan Qi Huan[1,2], Jonathan Kindem[1,2], John G. Bartholomew[1,2], Andrei Faraon[1,2]; *[1]Kavli Nanoscience Inst. and Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA; [2]Inst. for Quantum Information and Matter, California Inst. of Technology, USA.* We computationally characterize the superhyperfine energy structure of ^{171}Yb:YVO$_4$ and compare predicted holeburning spectra and coherence times with experimental data. Our simulation can help optimize coherence times for ensemble-based quantum memories and single-ion qubits.

JTu2A.27
Quantum Capacitors for Electronic Read-out in Spin-based Quantum Information Processing, Pouya Dianat[1], Bahram Nabet[1]; *[1]Drexel Univ., USA.* Quantum capacitors are demonstrated for gauging of quantum energy states, which provide an unprecedented electronic read-out for spintronic systems applied in quantum information processing.

JTu2A.28
BB84 and DQPS-QKD experiments using one polarization-insensitive measurement setup with a countermeasure against detector blinding and control attacks, Muataz M. Alhussein[1], Kyo Inoue[1], Toshimori Honjo[2]; *[1]Graduate School of Eng., Osaka Univ., Japan; [2]NTT Basic Research Labs, NTT Corporation, Japan.* This paper demonstrates phase-encoding BB84-based QKD experiments with active basis selection using one interferometer with no phase and polarization controls, unlike conventional BB84-QKD experiments. A countermeasure against detector blinding attack is also implemented.

JTu2A.29
Withdrawn

JTu2A.30
Solving the Untrusted Source Problem in Measurement-Device-Independent Quantum Key Distribution, Yucheng Qiao[1], Gan Wang[1], Zhengyu Li[1], Bingjie Xu[2], Bin Luo[3], Hong Guo[1]; *[1]Peking Univ., China; [2]Inst. of Southwestern Communication, China; [3]Beijing Univ. of Posts and Telecommunications, China.* We propose a light source monitoring scheme to solve the untrusted source problem in measurement-device-independent quantum key distribution, and show it performs almost the same as the initial protocol with a trusted source.

JTu2A.31
Generation of Continuous Variable Quantum Entanglement at 1550 nm and Distribution Over Optical Fiber, JinXia Feng[1,2], Hao Zhao[1], Dandan Nie[1], Yuanji Li[1,2], Kuanshou Zhang[1,2]; *[1]State Key Lab of Quantum Optics and Quantum Optics Devices, Inst. of Opto-Electronics, Shanxi Univ., China; [2]Collaborative Innovation Centre of Extreme Optics, Shanxi Univ., China.* Continuous variable quantum entanglement of 8.3 dB are experimentally generated and distributed over 20 km optical fiber. A theoretical prediction considering excess noise in fiber channel is in good agreement with the experimental results.

JTu2A.32
Single Qubit Gates on a Microfabricated Ion Chip Trap with Integrated Diffractive Optics, Erik W. Streed[1,2], Jordan Scarabel[1], Steven Connell[1], Kenji Shimizu[1], Valdis Blums[1], Marcin Piotrowski[1,3], Mirko Lobino[1,4]; *[1]Centre for Quantum Dynamics, Griffith Univ., Australia; [2]Inst. for Glycomics, Griffith Univ., Australia; [3]Manufacturing, CSIRO, Australia; [4]4Queensland Micro and Nanotechnology Centre, Griffith Univ., Australia.* ^{171}Yb$^+$ was trapped above a Fresnel mirror collimator. Integrated microwave rails provided a 68kHz Rabi rate on the 12.7 GHz transition with a 2.7 ms decoherence time. Doppler recooling measured a 27 quanta/ms heating rate.

JTu2A.33
Energy-Time Entanglement Based Dispersive Optics Quantum Key Distribution over Optical Fibers of 20 km, Xu Liu[1,2], Xin Yao[1,2], Heqing Wang[3], Hao Li[3], Lixing You[3], Yidong Huang[1,2], Wei Zhang[1,2]; *[1]Dept. of Electronic Engineering, Beijing National Research Center for Information Science and Technology (BNRist), Beijing Innovation Center for Future Chips, Electronic Engineering Dept., Tsinghua Univ., China; [2]Beijing Academy of Quantum Information Sciences, China; [3]State Key Lab of Functional Materials for Informatics, Shanghai Inst. of Microsystem and Information Technology, Chinese Academy of Sciences, China.* An energy-time entanglement based dispersive-optics quantum key distribution is demonstrated experimentally over 20 km optical fibers, in which photon pairs are generated by spontaneous four wave mixing in a silicon waveguide.

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.34
Withdrawn

JTu2A.35
Verifying hidden quantum steering via local filtering operations, Yong-Su Kim[1], Tanumoy Pramanik[1], Young-Wook Cho[1], Sang-Wook Han[1], Sang-Yun Lee[1], Sung Moon[1]; [1]*South Korea Inst. of Science & Technology, South Korea (the Republic of).* We theoretically and experimentally investigate the 'hidden' property of quantum steerability. In particular, we find that there are initially unsteerable states which can reveal the steerability by using local filtering operations on individual quantum systems.

JTu2A.36
Conversion of Position Correlation into Polarization Entanglement, Chithrabhanu Perumangatt[1], Alexander Lohrmann[1], Alexander Ling[1,2]; [1]*Centre for quantum technologies, India;* [2]*Physics, National Univ. of Singapore, Singapore.* The photons pairs generated by parametric down conversion of a laser beam have inherent position and momentum correlations. We generate bright, high fidelity polarization entangled photons by manipulating the position correlations using a Mach-Zehnder interferometer.

JTu2A.37
Bright Beams of Intensity Difference Squeezed Light for use in Sub-shot-noise Imaging, Rory W. Speirs[1], Nicholas R. Brewer[2], Meng-Chang Wu[1,3], Paul D. Lett[2]; [1]*Joint Quantum Inst., The Univ. of Maryland, USA;* [2]*Joint Quantum Inst., National Inst. of Standards and Technology, USA;* [3]*Inst. of Physical Science and Technology, The Univ. of Maryland, USA.* We present a method for using bright beams of intensity difference squeezed light to perform sub-shot-noise imaging. The intensity correlated twin beams are generated by four wave mixing in rubidium vapour.

JTu2A.38
Detection of 10 dB vacuum noise squeezing at 1064 nm by balanced homodyne detectors with a common mode rejection ratio more than 80 dB, Chien-Ming Wu[1], Shu-Rong Wu[1], Yi-Ru Chen[1], Hsun-Chung Wu[1], Ray-Kuang Lee[1]; [1]*National Tsing Hua Univ., Taiwan.* Quantum noise reduction up to 10 dB is observed, with the help of our home-made balanced homodyne detector (BHD), characterized with a Common Mode Rejection Ratio (CMRR) more than 80 dB.

JTu2A.39
Realization of optical isolator at room temperature in miniaturized vapor cell using light induced atomic desorption, Eliran Talker[1], P. Arora[1], Mark Dikopoltsev[1,2], Uriel Levy[1]; [1]*Dept. of Applied Physics, The Hebrew Univ. Jerusalem, Israel, Israel;* [2]*RAFAEL, Science Center, Rafael Ltd, Haifa(Israel), Israel.* A compact, on-chip atomic optical isolator using light induced atomic desorption technique is demonstrated. A millimeter size fabricated vapor cell integrated with small permanent magnets of ≈ 300 Gauss are used to realize an atomic optical isolator at room temperature.

JTu2A.40
GHz Photon-number-resolving Detection with InGaAs/InP APD, Yan Liang[1], Zhihe Liu[1], Qilai Fei[1], Heping Zeng[1,2]; [1]*USST, China;* [2]*East China Normal Univ., China.* Combining ultrashort gates and the robust spike-noise suppression technique, we demonstrate an InGaAs/InP APD based photon-number-resolving detector capable of distinguishing up to 3 photons with the detection efficiency as high as 40% at 1 GHz.

JTu2A.41
Generation and Detection of Down-converted Photon Pairs at 2.080 µm, Shashi Prabhakar[1], Taylor Shields[1], Damian Powell[1], Gregor G. Taylor[1], Dmitry Morozov[1], Mehdi Ebrahim[1], Michael Kues[1], Lucia Caspani[2], Corin Gawith[3], Robert H. Hadfield[1], Matteo Clerici[1]; [1]*School of Engineering, Univ. of Glasgow, UK;* [2]*Dept. of Physics, Univ. of Strathclyde, UK;* [3]*Covesion Ltd. & Optoelectronics Research Centre, Univ. of Southampton, UK.* We report the generation and coincidence-to-accidental ratio characterization of a pulsed spontaneous parametric down-conversion photon pair source at 2.080 µm, as a basis for free-space quantum communication in an atmospheric window with low solar background.

JTu2A.42
Generating polarization-entangled photon pairs in domain-engineered PPLN, Paulina S. Kuo[1], Varun B. Verma[2], Thomas Gerrits[2], Sae Woo Nam[2], Richard P. Mirin[2]; [1]*Information Technology Lab, NIST, USA;* [2]*Physical Measurement Lab, National Inst. of Standards and Technology, USA.* Using a periodically poled $LiNbO_3$ crystal that is domain-engineered for two simultaneous type-II down-conversion processes, we demonstrated polarization-entangled photon-pair generation.

JTu2A.43
Site-controlled InAs quantum dot for hetero-integration of single photon emitter, Young-Ho Ko[1], Won Seok Han[1], Kap-Joong Kim[1], Byung-Seok Choi[1], Kyu Young Kim[2], Je-Hyung Kim[2], Heeju Kim[3], Yudong Jang[3], Donghan Lee[3], Chun Ju Youn[1], Jong-Hoi Kim[1], Jung Jin Ju[1]; [1]*Electronics and Telecom Research Inst, South Korea (the Republic of);* [2]*Ulsan National Inst. of Science and Technology, South Korea (the Republic of);* [3]*Chungnam National Univ., South Korea (the Republic of).* For hetero-integration of single photon emitter with silicon photonics, the site-controlled quantum dot was obtained by selective-area growth. The integrated structure was designed as InAs quantum dot on the silicon waveguides with high coupling efficiency and fabricated by micro-transfer technique.

JTu2A.44
Non-phase Matched Spontaneous Parametric Down Conversion in Ultra-thin Lithium Niobate, Cameron S. Okoth[1,2], Tomas Santiago[1,2], Andrea Cavanna[1,2], Maria Chekhova[1,2]; [1]*Max-Planck Inst. for the Science of Light, Germany;* [2]*Physics, Univ. of Erlangen Nuremberg, Germany.* We report the generation of entangled photon pairs via type-0 spontaneous parametric down conversion in ultra-thin lithium niobate in which momentum between the pump photon and daughter photons is not conserved.

JTu2A.45
Observing the quantum Cheshire cat with a nondestructive weak measuring device, Yosep Kim[2], Dong-Gil Im[2], Yong-Su Kim[1], Sang-Yun Lee[1], Sang-Wook Han[1], Sung Moon[1], Yoon-Ho Kim[2], Young-Wook Cho[1]; [1]*South Korea Inst. of Science & Technology, South Korea (the Republic of);* [2]*Pohang Univ. of Science and Technology (POSTECH), South Korea (the Republic of).* In this work, we report the experimental observation of the quantum Cheshire cat effect with a nondestructive weak measuring device. A quantum pointer after the weak quantum measurement indicates that the polarization can be found at the path the photon did not take.

JTu2A.46
Design and Production of Femtosecond Laser Writable Borate-based Glasses for Photonic Devices, Antonio Dias[1], Francisco Muñóz[2], Asier Alvarez[1], Pedro Moreno-Zarate[3], Julia Atienzar[1], Ana Urbieta[4], Paloma Fernandez[4], Marina Garcia[1], Rosalia Serna[1], Javier Solis[1]; [1]*Instituto De Optica 'Daza De Valdes', Spain;* [2]*Ceramics and Glass Inst. (ICV, CSIC), Spain;* [3]*Engineering School, Tepexi Higher Technological Inst., Mexico;* [4]*Dept. of Materials Physics, Faculty of Physics, Univ. Complutense, Spain.* This work reports the design, synthesis, laser processing and performance of borate glasses that were compositionally designed to be femtosecond laser writable using laser-induced ion migration, leading to the production efficient optical waveguides.

JTu2A.47
Selective Delamination of Thin Films from Ceramic Surfaces upon Femtosecond Laser Ablation, Frederik Kiel[2], Nadezhda M. Bulgakova[1], Andreas Ostendorf[2], Evgeny Gurevich[2]; [1]*HiLASE, Inst. of Physics ASCR, Russia;* [2]*Applied Laser Technologies, Ruhr-Universität Bochum, Germany.* Experimental observation of selective delamination of YSZ ceramics upon femtosecond laser processing of its surface is reported. The delamination mechanism is identified as an interplay between beam defocusing by laser-generated free-electron plasma and Kerr nonlinearity.

JTu2A.48
High-Resolution Mid-Infrared Spectral Reconstruction using a Subwavelength Coaxial Aperture Array, Benjamin J. Craig[1], Jiajun Meng[1], Vivek R. Shrestha[1], Jasper Cadusch[1], Kenneth Crozier[1]; [1]*Univ. of Melbourne, Australia.* We demonstrate mid-infrared computational spectroscopy using an array of coaxial aperture filters. We experimentally determine material transmission spectra using an algorithm whose inputs are the transmission spectra and the power transmitted through each filter.

JTu2A.49
Monolithic integration of an electrically tunable ultrahigh-Q optomechanical device, Zhiwei Fang[1,4], Sanaul Haque[2], Jintian Lin[3], Rongbo Wu[3], Jianhao Zhang[3], Min Wang[1,4], Muniyat Rafa[2], Ya Cheng[1,4], Tao Lu[2]; [1]*State Key Lab of Precision Spectroscopy, East China Normal Univ., China;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Victoria, Canada;* [3]*State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, China;* [4]*XXL—The Extreme Optoelectromechanics Lab, East China Normal Univ., China.* We demonstrate an electrically tunable ultrahigh-Q optomechanical device (mechanical $Q{\sim}2.76{\times}10^5$) for the mechanical mode at 100.32 MHz by monolithically integrating an on-chip lithium niobate microresonator (optical $Q{\sim}10^7$) with a pair of in-plane microelectrodes.

JTu2A.50
Laser-Induced-Modification Raman Spectroscopy for Probing Microscopic Structural Variation Beyond Conventional Techniques: CZTSe as an Example, Qiong Chen[1], Yong Zhang[1]; [1]*UNC-Charlotte, USA.* Laser-induced-modification Raman spectroscopy coupled with high spatial resolution and high-temperature capability is demonstrated to obtain additional structure information beyond what the conventional techniques offer, revealing microscopic scale variation between nominally similar alloys.

JTu2A.51
Graphene-coated Suspended Metallic Nanostructures for Fast and Sensitive Optomechanical Infrared Detection , Mohammad Wahiduzzaman Khan[1], Parinaz Sadri Moshkenani[1], Md Shafiqul Islam[1], Ozdal Boyraz[1]; [1]*Univ. of California Irvine, USA.* We investigate the effect of incorporating graphene in suspended metallic nanostructures for radiation detection. We have found enhanced absorptance resulting in increased sensitivity and faster operation owing to graphene's extraordinary plasmonic and thermal properties.

JTu2A.52
Room Temperature Control of Valley Coherence in Bilayer WS_2 Exciton Polaritons, Mandeep Khatoniar[1,4], Nicholas Yama[2], Areg Ghazaryan[3], Sriram Guddala[4], Pouyan Ghaemi[4,1], Vinod Menon[4,1]; [1]*Physics, Graduate Center, USA;* [2]*Physics, Univ. of Hawaii at Manoa, USA;* [3]*Physics, IST Austria, Austria;* [4]*Physics, City College of New York, USA.* We demonstrate robust retention of valley coherence and its control via polariton pseudospin precession through the optical TE-TM splitting in bilayer WS_2 microcavity exciton polaritons at room temperature.

JTu2A.53
Laser Interaction in Additive Manufacturing of Optics and Photonics, Nicholas Capps[2], Jason Johnson[1], Jonathan Goldstein[3], Edward Kinzel[2,1]; [1]*Missouri Univ. of Sci. and Tech., USA;* [2]*Aerospace and Mechanical Engineering, Univ. of Notre Dame, USA;* [3]*Air Force Research Labratory, USA.* The laser/glass interaction in Fiber-Fed Laser-Heated Additive Manufacturing is studied. Specifically, the effects of the laser wavelength, power, and interaction time are considered experimentally and using numeric models.

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.54
Femtosecond Laser- Colorized AZO Films on Flexible Mica Substrates, Chih Wei Luo[1], Hung Yang[1], Tien-Tien Yeh[1], Chien-Ming Tu[1]; [1]*National Chiao Tung Univ., Taiwan.* Laser-colorized aluminum-doped zinc oxide (AZO) films are fabricated using femtosecond laser annealing. By varying the laser fluences, ripple-like nanostructures are generated on the surface of AZO films, which produces cyan, yellow and orange colors.

JTu2A.55
Phase Retardance and Broadband Spatio-Spectral Overlap of Chiral Hybrid Modes on Large-Area Nanofingernails, Aneek Biswas[2], Paulina Librizzi[3], Ilona Kretzschmar[3], Luat Vuong[1]; [1]*Univ. of California at Riverside, USA;* [2]*Physics, City Univ. New York, USA;* [3]*Chemical Engineering, City Univ. New York, USA.* Unusually-broadband excitations of chiral hybrid modes on micropore nanofingernails exhibit phase retardation effects, which spatially overlap intensity hotspots across the visible and NIR spectrum. We demonstrate that enhanced chiral scattering occurs without circular dichroism.

JTu2A.56
Optical Detection of Deuterium in Heavy Water: Towards Remote Detection of Tritium, Milos Burger[1], Patrick J. Skrodzki[1], Lauren A. Finney[1], Jörg Hermann[2], John Nees[1], Igor Jovanovic[1]; [1]*Univ. of Michigan, USA;* [2]*Aix-Marseille Univ., CNRS, LP3, France.* Tritium detection poses a challenge because of the weak beta particle emission and absence of ionizing radiation. We demonstrate the isotopic analysis of deuterated water via laser-induced breakdown spectroscopy as a modality for measuring tritium.

JTu2A.57
Scattered Complex Laguerre-Gaussian Spectrum to Determine the 2-D Transverse Position of a Spherical Silica Particle, Runzhou Zhang[1], Hao Song[1], Zhe Zhao[1], Haoqian Song[1], Jing Du[1], Guodong Xie[1], Long Li[1], Kai Pang[1], Cong Liu[1], Ahmed Almaiman[1], Shlomo Zach[2], Nadav Cohen[2], Moshe Tur[2], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*Tel Aviv Univ., Israel.* We study the complex Laguerre-Gaussian (LG) spectrum of single-silica-particle-scattered light by finite-difference-time-domain (FDTD) simulation. We find that complex LG spectrum can be potentially utilized for 2-dimensional localization of a dielectric spherical particle.

JTu2A.58
Multi-shot and Single-shot Time-resolved Visualization of Material Modification During Laser Micromachining With Flexible Glass, Dennis Dempsey[1], Garima C. Nagar[1], James S. Sutherland[2], Rostislav I. Grynko[1], Bonggu Shim[1]; [1]*Binghamton Univ., USA;* [2]*Corning Research & Development Corporation, USA.* We visualize material modification during laser micromachining, in particular, laser waveguide fabrication in flexible Corning® Willow® Glass via time-resolved interferometry, and single-shot frequency-domain holography which is a robust technique for studying permanent material change/damage.

JTu2A.59
Joule-level 10 Hz non-collinear multi-pumps SBS amplifier with high combining efficiency used for laser beams combination, Can Cui[1], Yulei Wang[1], Zhiwei Lu[1], Zhenxu Bai[1], Yue Wang[1], Hang Yuan[1]; [1]*Harbin Inst. of Technology, China.* We demonstrated the non-collinear SBS amplifier with the energy extraction efficiency up to 70% and the output of 2.5 J at 10 Hz. Multiple pumps and the increase of optical intensity enhance the performance of the amplifier.

JTu2A.60
A Superluminal Raman Laser with Enhanced Cavity Length Sensitivity, Zifan Zhou[1], Minchuan Zhou[1], Selim M. Shahriar[1]; [1]*Northwestern Univ., USA.* We demonstrate experimentally an optically pumped Raman laser with a self-pumped Raman depletion employing two isotopes of rubidium, achieving an inferred spectral sensitivity to cavity length change by a factor of more than a thousand.

JTu2A.61
Cavity-External Spatial Gain Shaping for Selective Higher-Order Mode Excitation, Florian Schepers[1], Tim Bexter[1], Tim Hellwig[1], Carsten Fallnich[1,2]; [1]*Inst. of Applied Physics, Univ. of Muenster, Germany;* [2]*MESA+ Inst. of Nanotechnology, Univ. of Twente, Netherlands.* We present cavity-external spatial gain shaping based on a digital micromirror device for the selective and realignment-free excitation of nearly 1000 different single Hermite-Gaussian modes in an end-pumped Nd:YVO_4.

JTu2A.62
Direct generation of vortex beams from a diode-pumped Pr^{3+}:YLF laser, Yuanyuan Ma[1], Jung-Chen Tung[2], Katsuhiko Miyamoto[1,3], Takashige Omatsu[1,3]; [1]*Chiba Univ., Japan;* [2]*National Chiao Tung Univ., Taiwan;* [3]*MCRC Chiba Univ., Japan.* We have demonstrated the direct generation of 100 mW level visible scalar and vector vortex modes from a diode-pumped Pr^{3+}:YLF laser by employing an off-axis pumping technique.

JTu2A.63
High-order actively mode-locked picosecond fiber laser and Poisson single-photon source, H. Y. Wang[1], Zhengyong Li[1], X. K. Zhan[1], S. C. Wang[1], B. C. Wang[1]; [1]*Beijing Jiaotong Univ., China.* We demonstrate the 200th-order actively mode-locked picosecond fiber laser based on nonlinear polarization rotation in a semiconductor optical amplifier with GHz repetition frequency and 1.63-ps pulse width, which produces a Poisson single-photon source.

JTu2A.64
Pulse compression of multiple plate continuum at 1.55 µm, Chia-Lun Tsai[1], Yi-Hsun Tseng[1], An-Yuan Liang[1], Jhan-You Guo[1], Ming-Wei Lin[1], Shang-Da Yang[1], Ming-Chang Chen[1]; [1]*Natl Tsing Hua Univ, Taiwan.* We experimentally demonstrated nonlinear pulse compression at 1.55 µm from 80 fs to 28 fs by using multiple plate continuum generation and femtosecond pulse shaping.

JTu2A.65
Compensation of Frequency Modulation to Amplitude Modulation Conversion in Regenerative Amplifier, Elodie Boursier[1], Sébastien Montant[1], Jacques Luce[1], Eric Lavastre[1], Denis Penninckx[1]; [1]*CEA CESTA, France.* This work deals with the compensation of FM-to-AM conversion induced by the spectral response of regenerative cavity. We show that it is possible to reduce amplitude modulations from 44% to 9% using an interference filter.

JTu2A.66
Ultrastable laser based on multi-cavity, Lulu Yan[1,2], Yanyan Zhang[1,2], Pan Zhang[1], Songtao Fan[1,2], Xiaofei Zhang[1,2], Wenge Guo[1], Shougang Zhang[1,2], Haifeng Jiang[1,2]; [1]*National Time Service Center, China;* [2]*Univ. of Chinese Academy of Sciences, China.* We report a proposal of developing ultrastable laser referenced to multi-cavity, reducing thermal noise by averaging effect of beam size. We perform an experiment to simulate a two-cavity system and obtained the instability is 5×10^{-16}@1s, improved by a factor of √2 from a single cavity system.

JTu2A.67
Generating a Twisted Spatiotemporal Wave Packet Using Coherent Superposition of Structured Beams with Different Frequencies, Zhe Zhao[1], Runzhou Zhang[1], Hao Song[1], Haoqian Song[1], Long Li[1], Jing Du[1], Cong Liu[1], Kai Pang[1], Ahmed Almaiman[1], Robert Boyd[2], Moshe Tur[3], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*Univ. of Rochester, USA;* [3]*Tel Aviv Univ., Israel.* We explore the superposition of different LG modes located on different frequencies to control the wave packet's spatiotemporal structures in simulation. Dependence of its rotating helical envelope on the mode and frequency spectra is analyzed.

JTu2A.68
Development of an Actively Cooled Glass Amplifier at GSI, Marco Patrizio[1], Vincent Bagnoud[2,3], Bernhard Zielbauer[2], Markus Roth[1,4]; [1]*Nuclear Physics, TU Darmstadt, Germany;* [2]*Plasma Physics, GSI Helmholtz Centre for Heavy Ion Research, Germany;* [3]*Helmholtz Inst. Jena, Germany;* [4]*Facility for Antiproton and Ion Research (FAIR), Germany.* Increasing the repetition rate of a large aperture glass amplifier requires active cooling systems. We present our cooling concept, potential coolants and simulation results achieving an increase in repetition rate by a factor of 10.

JTu2A.69
Beam Pointing Detection by Interference with a Frequency Shifted Higher-Order Mode, Florian Schepers[1], Tim Brüggenkamp[1], Tim Hellwig[1], Carsten Fallnich[1,2]; [1]*Univ. of Muenster, Germany;* [2]*MESA+ Inst. of Nanotechnology, Univ. of Twente, Netherlands.* We present the beam pointing detection of a fundamental mode by a superposition with a frequency-shifted higher-order Hermite-Gaussian mode and experimentally demonstrate its applicability for stabilization of beam position.

JTu2A.70
Modulation Bandwidth Enhancement and Chirp Reduction in DFB Lasers with Active Optical Feedback, Yuanfeng Mao[1], Wu Zhao[1], Jiankun Wang[1], Hao Wang[1], Yongguang Huang[1], Dan Lu[1], Chen Ji[1], Qiang Kan[1], Wei Wang[1]; [1]*Inst. of Semiconductors, CAS, China.* 1.55-µm DFB lasers with active optical feedback exhibits high modulation bandwidth and reduced frequency chirp. 25-Gb/s clearly open eyes and 10-km SMF error-free transmission with small power penalty was achieved.

JTu2A.71
Continuous Wave Amplified Spontaneous Emission from Mixed Cation Perovskite devices, Philipp Brenner[2], Ofer Bar-On[1], Marius Jakoby[2], Isabel Allegro[2], Bryce Richards[2], Ulrich Paetzold[2], Ian Howard[2], Jacob Scheuer[1], Uli Lemmer[2]; [1]*Tel-Aviv Univ., Israel;* [2]*KIT, Germany.* Amplified spontaneous emission from perovskite devices is demonstrated under continuous wave (CW) pumping. The devices are based on mixed cation perovskites, which preserve their phase in temperature, constituting a crucial step towards practical perovskite photonics.

JTu2A.72
High-Power Wide-Bandwidth 1.55-µm Directly Modulated DFB Lasers for Free Space Optical Communications, Hao Wang[1,2], Ruikang Zhang[1], Qiang Kan[1], Dan Lu[1], Wei Wang[1], Lingjuan Zhao[1]; [1]*Inst. of Semiconductors, Chinese Academy of Sciences, China;* [2]*Univ. of Chinese Academy of Sciences, China.* Single-mode directly modulated distributed feedback (DFB) lasers working at 1.55-µm with high power of 160 mW output, SMSR beyond 50 dB and large bandwidth of 8.5 GHz are demonstrated.

JTu2A.73
Fast physical random bit generation using broadband chaos generated by self-phase-modulated external-cavity semiconductor laser cascaded with microsphere resonator, Ning Jiang[1], Anke Zhao[1], Yajun Wang[1], Shiqin Liu[1], Chenpeng Xue[1], Kun Qiu[1]; [1]*Univ of Electronic Science & Tech China, China.* We experimentally demonstrate a broadband chaos generation using semiconductor laser subject to self-phase-modulation and microsphere resonator, and a subsequent fast physical random bit generation beyond 300-Gbps by using the broadband chaos as entropy source.

JTu2A.74
All-optical Inhibitory Integrate and Fire Neuron based on a Single-Section Quantum-Dot Semiconductor Laser, Menelaos Skontranis[1,2], George Sarantoglou[2], Charis Mesaritakis[1,2]; [1]*Information and Communication Systems Engineering, Univ. of the Aegean, Greece;* [2]*Informatics & Telecommunications, National & Kapodistrian Univ. of Athens, Greece.* Numerical results concerning all optically triggered inhibitory neurons based on single-section InAs/InGaAs quantum-dot lasers are demonstrated. The devices are isomorphic to biological fire and integrate inhibitory neurons, offering picosecond spikes and wavelength encoding of neural signals.

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.75
Vertical Metasurface integrated Cavity Surface-Emitting Lasers (VMCSELs) for collimated lasing emissions, Yiyang Xie[2], Peinan Ni[1], Qiuhua Wang[2], Chen Xu[2], Qiang Kan[3], Hongda Chen[3], Patrice Genevet[1]; [1]*CNRS, France;* [2]*BJUT, China;* [3]*Inst. of Semiconductor, China.* In this work, vertical metasurface integrated cavity surface-emitting lasers (VMCSELs) have been proposed and designed into back-emitting configuration. We have demonstrated that the integration with metasurface allows the effective control of the lasing emission wavefront.

JTu2A.76
Modelling Directly Reflectivity Modulated Lasers, Guangyao Liu[2,1], Argishti Melikyan[2], S.J.Ben Yoo[1], Po Dong[2]; [1]*Univ. of California Davis, USA;* [2]*Nokia Bell Labs, USA.* We present the numerical modelling of directly reflectivity modulated laser with high speed modulated mirrors in the time domain for both static and dynamic laser performance.

JTu2A.77
Controlling Light Amplification of Colloidal Quantum Dot in Actively Operating Device, Junhong Yu[1], Sushant Shendre[1], Weon-kyu Koh[1], Baiquan Liu[1], Songyan Hou[1], Chathuranga Hettiarachchi[1], Savas Delikanli[1], Pedro H. Martínez[1], Muhammad D. Birowosuto[1], Hong Wang[1], Hilmi V. Demir[1,2], Cuong DANG[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Bilkent Univ., Turkey.* By applying an external electric field to CQDs, we have demonstrated tunable amplified spontaneous emission (ASE) threshold in a long-sought practical device. Our results open new possibilities for achieving zero-threshold and electrically pumped CQD lasers.

JTu2A.78
A Gain-Embedded Meta-Mirror, Mansoor Sheik-Bahae[1], Zhou Yang[1], Alexander R. Albrecht[1], David Lidsky[1]; [1]*Univ. of New Mexico, USA.* We propose an active mirror structure based on a dielectric high-contrast grating reflector combined with optical gain. This structure is designed to be directly bonded to a thermal substrate for efficient heat removal, thus allowing semiconductor disk lasers with kW output power.

JTu2A.79
Four-Channel Hybrid Silicon Laser Array with low power consumption for on-chip optical interconnects, Hongyan Yu[1], Yajie Li[1], Chaoyang Ge[2], Xuliang Zhou[1], Guangzhao Ran[2], Jiaoqing Pan[1]; [1]*CAS Inst. of Semiconductors, China;* [2]*The State Key Lab for Mesoscopic Physics and School of Physics, Peking Univ., China.* A four-wavelength silicon hybrid laser array with a buried ridge stripe (BRS) structure is demonstrated with a threshold current less than 10 mA and a side-mode suppression ratio higher than 40 dB at room temperature.

JTu2A.80
Polarization Stable VCSEL Based on Integration of Subwavelength Gratings with Low Refractive Index Medium, Qiuhua Wang[1], Yiyang Xie[1], Chen Xu[1], Guanzhong Pan[1]; [1]*Beijing Univ. of Technology, China.* A polarization stable VCSEL was realized by etching sub-wavelength gratings structure and depositing a low refractive index layer on the surface. The fabricated VCSEL is of low threshold and high polarization power ratio of 123:1.

JTu2A.81
Low Threshold Current Photonic Crystal Surface Emitting Lasers with Beam Modulation Capability, Lih-Ren Chen[1], Han-Lun Chiu[1], Kuo-Bin Hong[1], Tien-Chang Lu[1]; [1]*Dept. of Photonics, National Chiao Tung Univ., Taiwan.* We proposed a GaAs-based photonic crystal surface emitting laser with naturally formed periodic structures on the ITO top cladding layer. Low threshold current density and ability of beam modulation have been demonstrated.

JTu2A.82
Toward All MOCVD Grown InAs/GaAs Quantum Dot Laser on CMOS-compatible (001) Silicon, Lei Wang[1], Bei Shi[1], Hongwei Zhao[1], Simone S. Brunelli[1], Bowen Song[1], Douglas Oakley[1], Jonathan Klamkin[1]; [1]*Univ. of California, Santa Barbara, USA.* Indium arsenide quantum dots (QDs) are demonstrated on gallium arsenide on silicon templates by metalorganic chemical vapor deposition. The template threading dislocation density is only 9.5×10^{6} cm^{-2} and the QDs are of high quality.

JTu2A.83
High-Order Phase-Matching Enabled Octave-Bandwidth Four-Wave Mixing in AlGaAs-On-Insulator Waveguides, Yong Liu[1], Michael Galili[1], Kresten Yvind[1], Leif K. Oxenløwe[1], Hao Hu[1], Minhao Pu[1]; [1]*Dept. of Photonics Engineering, Tec, Denmark.* We show in simulation an ultra-broad continuous four-wave mixing conversion band over an octave span (covering 1.1-2.5 µm wavelength range) by taking advantage of the high-order phase-matching and the ultra-high effective nonlinearity of AlGaAs-on-insulator waveguides.

JTu2A.84
Avoidance of Cross-Phase Modulation in Femtosecond Stimulated Raman Scattering, Thomas Würthwein[1], Niels Irwin[1], Carsten Fallnich[1,2]; [1]*Inst. of Applied Physics, Germany;* [2]*MESA+ Inst. of Nanotechnology, Netherlands.* The influence of cross-phase modulation on stimulated Raman scattering in the high peak power regime is investigated, resulting in optimized pulse parameters for reduced cross-phase modulation artefacts.

JTu2A.85
Evolutionary Algorithm Assisted Design of an Elliptical Focusing Build-up Cavity Avoiding the Degradation Problem in BBO, Daniel Preissler[1], Daniel Kiefer[1], Thorsten Führer[1], Thomas Walther[1]; [1]*Technische Universität Darmstadt, Germany.* We report on the design of a novel cavity with cylindrical focusing to overcome crystal degradation effects in the generation of UV radiation using evolutionary algorithms. Experimental results show the advantages of the new set-up.

JTu2A.86
pyLLE: a Fast and User Friendly Lugiato-Lefever Equation Solver, Gregory Moille[1], Qing Li[1], Xiyuan Lu[1], Kartik Srinivasan[2]; [1]*NIST/UMD, USA;* [2]*NIST, USA.* We present the development of pyLLE, a freely accessible Lugiato-Lefever equation solver programmed in Python and Julia and optimized for the simulation of microresonator fre- quency combs. Examples illustrating its operation and performance are presented.

JTu2A.87
Non-linear Optics and Harmonic Generation in ZnS Using Femtosecond Mid-IR Pulses Near Zero Dispersion Wavelength, Michael Tripepi[1,2], Aaron Schweinsberg[3], Kevin Werner[1], Noah Talisa[1], Laura Vanderhoef[3], Christopher Wolfe[3], Trenton Ensley[4], Anthony Valenzuela[3], Enam Chowdhury[1]; [1]*Dept. of Physics, The Ohio State Univ., USA;* [2]*Materials and Manufacturing Directorate, Air Force Research Labs, USA;* [3]*Weapons and Materials Research Directorate, U.S. Army Research Lab, USA;* [4]*Sensors and Electron Devices Directorate, U.S. Army Research Lab, USA.* Using intense 3.6 mm, 200 fs, 500 Hz laser pulses, non-linear spectral broadening, filamentation and 2nd-9th harmonic generation in ZnS (Cleartran™) with 3-40 mm propagation distance were observed. Non-linear index of Cleartran was also measured.

JTu2A.88
Above-Octave Supercontinuum Generation in a Hybrid Nonlinear Waveguide for On-Chip Cascaded Third- and Second-Order Nonlinear-Optic Applications, Guillermo Fernando Camacho Gonzalez[1], Marcin Malinowski[1], Amirmahdi Honardoost[1,2], Sasan Fathpour[1,2]; [1]*CREOL, Univ. of Central Florida, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Central Florida, USA.* It is shown that over 1.25 octaves supercontinuum is attainable in a hybrid chalcogenide-glass/lithium-niobate miniaturized waveguide platform that allows cascaded third- and second-order optical nonlinearities on a monolithic chip, particularly for frequency-stabilized integrated comb sources.

JTu2A.89
1.7-µm high-power laser generation from a thulium-assisted optical parametric oscillator (TAOPO) for bond-selective photoacoustic microscopy, Jiawei Shi[1], Can Li[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong.* We present a high-power thulium-assisted optical parametric oscillator (TAOPO), which provides a pulse energy of 146 nJ with a duration of 2 ns at 1.7-µm window. It is a promising exciting source for bond-selective photoacoustic microscopy.

JTu2A.90
Kerr Comb Generation in Raman Effect Dominated Microresonators, Yanzhen Zheng[1], Changzheng Sun[1], Bing Xiong[1], Lai Wang[1], Jian Wang[1], Yanjun Han[1], Zhibiao Hao[1], Hongtao Li[1], Yi Luo[1]; [1]*Dept. of Electronic Engineering, Tsinghua Univ., China.* We propose a method to suppress Raman effect in microresonators by incorporating a filter structure. Numerical simulations based on Lugiato-Lefever equation confirm the effectiveness of the design for soliton frequency comb generation at microwave rates.

JTu2A.91
Multi-octave-spanning supercontinuum generation in lead fluoride crystal, Yuxia Yang[1,2], Hongbo Cai[1,2], Meisong Liao[1,2], Yasutake Ohishi[3], Wanjun Bi[1,2], Xia Li[1,2], Takenobu Suzuki[3]; [1]*Key Lab of Materials for High Power Laser, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Univ. of Chinese Academy of Sciences, China;* [3]*Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan.* We report the filamentation and supercontinuum generation of femtosecond pulse in a piece of PbF_2 crystal with high bandgap and ultra-broadband frequency window. A broadband supercontinuum spanning from 350 to 9000 nm is demonstrated.

JTu2A.92
High-power High-efficiency Second Harmonic Generation of 1342-nm Laser in LBO and PPKTP, Xingyang Cui[1,2], Qi Shen[1,2], Mei-Chen Yan[1,2], Chao Zeng[1,2], Tao Yuan[1,2], Wen-Zhuo Zhang[1,2], Xing-Can Yao[1,2], Cheng-Zhi Peng[1,2], Xiao Jiang[1,2], Yu-ao Chen[1,2], Jian-Wei Pan[1,2]; [1]*Shanghai Branch, National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Chinese Academy of Sciences (CAS) Center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, Univ. of Science and Technology of China, China.* We present a high-efficiency extra-cavity SHG of high-power CW 1342-nm laser. By employing LBO and PPKTP, we obtained the output power up to 3.3W and 5.2W with the conversion efficiency of 57.9% and 93.8%, respectively.

JTu2A.93
Spectral Modulations in a Picosecond OPO Based on a Chirped Quasi-Phase Matched Crystal, Guillaume Walter[1], Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Cyril Drag[2], Antoine Godard[1]; [1]*Office Natl d'Etudes Rech Aerospatiales, France;* [2]*Laboratoire de physique des Plasmas, France.* We investigate and model spectral modulations that are specific features of OPOs based on chirped quasi-phase matched crystals. Their occurrence is related to cascaded three-wave mixing processes that are quasi-phase matched at different positions.

JTu2A.94
Deterministic Single Soliton Generation without Frequency Tuning in a Graphene-FP Microresonator, Zeyu Xiao[1], Kan Wu[1], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China.* A novel microresonator based on Fabry–Pérot resonator and monolayer graphene has been proposed. This design allows deterministic single soliton generation without frequency tuning and has strong robustness under frequency and timing jitter.

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.95
Yb-Fiber Laser Pumped Optical Parametric Sources Using LBO Crystals, Pancho Tzankov[1], Jeff Kmetec[1], Igor Samartsev[2], Valentin P. Gapontsev[2]; [1]*Silicon Valley Technology Center, IPG Photonics, USA;* [2]*IPG Photonics, USA.* Green-pumped OPG/OPAs and OPO using non-critical phase-matching in LBO are investigated at various pulse durations from 1ps to 13ns. The OPAs and OPO achieve similar conversion efficiencies of ~50% providing up to 25W output power.

JTu2A.96
Optimization of Si-Photonics Compatible AlN waveguides for Integrated Nonlinear Optics Applications, Aleem M. Siddiqui[1], Daniel Dominguez[1], Christopher Michael[1], Ryan Sims[1], Paul Stanfield[1], Lisa Anne Plucinski Hackett,[1], Andrew J. Leenheer[1], Matt Eichenfield[1]; [1]*Sandia National Labs, USA.* We explore fabrication-process dependencies on optical losses of AlN films and demonstrate Second Harmonic Generation through modal phase-matching in integrated AlN waveguides. A loss-dependent conversion efficiency model is developed to better design waveguides in lossy AlN media.

JTu2A.97
A Quasi-Autocorrelation System Based on Carbon-Nanotube Saturable Absorber, Pushan Xiao[1], Kan Wu[1], Dong Mao[2], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China;* [2]*Northwestern Polytechnical Univ., China.* Quasi-autocorrelation system based on carbon-nanotube saturable absorber is demonstrated at 1550nm with 75fJ pulses measured. The nanometer-level thickness and femtosecond-level decay time of nanomaterials allow compact and ultrafast light interaction for future chip-scale pulse characterization.

JTu2A.98
Tunable Parametric Optical Frequency Combs Generation based on an Electroabsorption Modulated Laser, Yumin Cheng[1], Juanjuan Yan[1], Zheng Zheng[1], Siyu Zhao[1]; [1]*Beihang Univ., China.* A scheme for parametric optical frequency combs generation with high tunability based on an electroabsorption modulated laser is proposed and experimentally demonstrated. Combs with a tunable spacing and an adjustable center frequency are obtained.

JTu2A.99
Exciton mediated ultrafast feature of hybrid 2D perovskite THz metadevice, Abhishek Kumar[1], Ankur Solanki[1], Manukumara Manjappa[1], Yogesh K. Srivastava[1], Tze C. Sum[2], Ranjan Singh[2]; [1]*Division of Physics and Applied Physics, Nanyang Technological Univ. Singapore, Singapore.* We show exciton mediated ultrafast feature in 2D perovskite arises due to quantum confinement of free carriers. Integrating it with metamaterials exhibit 93 % modulation of terahertz field at ultrafast time scales (~ 20 ps).

JTu2A.100
Efficient Graphene Based Ultrafast Field Detector Using Very Slow Electronics, Velat Kilic[1], Jacob Khurgin[1]; [1]*Johns Hopkins Univ., USA.* We propose an efficient novel graphene based terahertz field detector architecture which relies on slow electronics to detect the shape of ultrafast pulses. Measurements from an array of slow detectors can be posed as a nonlinear Fredholm integral and the inverse problem can be numerically solved.

JTu2A.101
THz Induced Ultrafast Dynamic in Liquid Jets, Semyon Germanskiy[1], Peter Zalden[2,3], Nilesh Awari[1,4], Mohammed Bawatna[1], Min Chen[1], Jan-Christoph Deinert[1], Bertram Green[1], Igor Ilyakov[1], Sergey Kovalev[1], Zhe Wang[1], Franz Kärtner[2,5], Christian Bressler[2,3], Michael Gensch[1]; [1]*Helmholtz-Zentrum Dresden-Rossendorf, Germany;* [2]*Centre for Ultrafast Imaging CUI, Univ. of Hamburg, Germany;* [3]*European XFEL, Germany;* [4]*Univ. of Groningen, Netherlands;* [5]*Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron, Germany.* We show measurements of THz induced ultrafast molecular dynamics in various liquids and solutions. Making use of a narrowband high-field highrepetition-rate THz source measurements can be performed in liquid jets with a high signal-to-noise ratio.

JTu2A.102
LT-GaAs-based photomixers with > 2 mW peak output power in the 220-325 GHz frequency band, Fuanki Bavedila[1], Etienne Okada[1], Jean-François Lampin[1], Guillaume Ducournau[1], Emilien Peytavit[1]; [1]*IEMN, France.* It is shown in this communication that a LT-GaAs photomixer based on an optically resonant cavity is able to generate peak output powers above 2 mW in the 220-325 GHz frequency band.

JTu2A.103
Withdrawn

JTu2A.104
Generation of >30 kW radiation at 5.7 THz from seeded KTP off-axis THz parametric oscillator, MingHsiung Wu[1], Wei Che Tsai[1], Yu Chung Chiu[1], Yen Chieh Huang[1]; [1]*National Tsing Hua Univ., Taiwan.* We report generation of >30 kW radiation at 5.7 THz from a KTP off-axis THz parametric oscillator, when pumping and seeding it with 13.7-mJ and 7-mJ laser pulses at 1064 and 1085.9 nm, respectively.

JTu2A.105
Efficient multicycle THz generation using a dedicated frequency-comb laser, Halil T. Olgun[3,1], Wenlong Tian[3,2], Damian Schimpf[3], Yi Hua[3,4], Aram Kalaydzhyan[3], Nicholas Matlis[3], Franz Kartner[3,4]; [1]*Helmholtz-Institut Jena, Germany;* [2]*School of Physics and Optoelectronic Engineering, China;* [3]*Center for Free-Electron Laser Science, DESY, Germany;* [4]*The Hamburg Centre for Ultrafast Imaging, Germany.* We develop a unique multi-line frequency-comb source designed for multi-millijoule, high-efficiency multicycle THz generation perform first experiments multi-line generation and control.

JTu2A.106
Femtosecond-laser-written circular waveguides in MgO-doped stoichiometric $LiTaO_3$, Shunsuke Watanabe[1], Junji Hirohashi[1], Koichi Imai[1], Masayuki Hoshi[1], Satoshi Makio[1]; [1]*OXIDE Corporation, Japan.* We fabricated depressed cladding circular waveguides by direct femtosecond laser writing with various pulse energies in MgO-doped stoichiometric $LiTaO_3$. The waveguiding properties were characterized with a CW laser at the wavelength of 1064 nm.

JTu2A.107
Magneto-Optical Faraday Effect of Dy^{3+} Doped Germanate-Phosphate Glasses, Masoud Mollaee[1], Xiushan Zhu[1], David Zelmon[2], Jie Zong[1], Michael Li[3], Arturo Chavez[3], Nasser Peyghambarian[1]; [1]*Univ. of Arizona, USA;* [2]*Air Force Research Lab, Wright-Patterson Air Force Base, USA;* [3]*NP Photonics Inc., USA.* Highly dysprosium doped germanate-phosphate glasses were fabricated, and their magneto-optical properties were measured. The measurement results show that highly dysprosium doped germinate-phosphate glass is a promising magneto-optical material in SWIR region.

JTu2A.108
2D crystal MXene $Ti_3C_2T_x$ based all-optical modulator, Qing Wu[1], Meng Zhang[1], Si Chen[2], Xiantao Jiang[2], Yunzheng Wang[2], Zheng Zheng[1], Han Zhang[2]; [1]*Beihang Univ., China;* [2]*Shenzhen Univ., China.* We demonstrate an all-fiber all-optical modulator at 1550 nm using MXene $Ti_3C_2T_x$ (T = F, O, or OH) deposited microfiber. The modulator features a slope efficiency of 0.061 π/mW and a rise time constant of 4.10 ms.

JTu2A.109
Resonant laser printing by Silicon crystallization and oxidation, Joseph A. Staif[1,2], Jonathan Bar-David[1,2], Jacob Engelberg[1,2], Noa Mazurski[1,2], Atzmon Vakahi[2], Sergei Remennik[2], Inna Popov[2], Anders Kristensen[3], Uriel Levy[1,2]; [1]*Applied Physics, Hebrew Univ., Israel;* [2]*Center for Nanoscience and Nanotechnology, Hebrew Univ., Israel;* [3]*Micro- and Nanotechnology, Technical Univ. of Denmark, Denmark.* The absorption in amorphous silicon nano antennas is engineered for the purpose of post process structural change via resonant laser printing by illumination, thus shifting transmission and reflection spectrum in a controlled manner.

JTu2A.110
Material Characterization and Thermal Performance of Au Alloys in a Thin-Film Plasmonic Waveguide, Frank Bello[1,2], Okan K. Orhan[1], Nicolas Abadia[3,4], David O'Regan[1], John Donegan[1,2]; [1]*School of Physics, Trinity College Dublin, Ireland;* [2]*Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Ireland;* [3]*School of Physics and Astronomy, Cardiff Univ., UK;* [4]*Inst. for Compound Semiconductors, UK.* We investigate heatsinking methods and material properties of various Au alloys to be used within thin-film plasmonic resonators to create optimal heating conditions in near-field transducers, with demonstrated application towards heat-assisted magnetic recording devices.

JTu2A.111
Single Nitrogen Vacancy Color Centers Generated by Femtosecond Laser Illumination on Diamond, Youying Rong[1], Zhiping Ju[1], Qiang Ma[1], Shikang Liu[1], Chengda Pan[1], Botao Wu[1], Haifeng Pan[1], E Wu[1]; [1]*East China Normal Univ., China.* By focusing high-power femtosecond laser on diamond surface coated with a layer of nano-silicon powder, single nitrogen vacancy centers could be fabricated efficiently around the illuminated craters even without annealing.

JTu2A.112
Enhanced Photoluminescence Intensity and Negative Photoconductivity in Lysine-Doped Graphene Oxide Quantum Dots, Svette Reina Merden S. Santiago[1], Tzu-Neng Lin[1], Yun-Syuan Chou[1], Ji-Lin Shen[1]; [1]*Chung Yuan Christian Univ., Taiwan.* We present a facile synthesis of lysine-doped graphene oxide quantum dots (GOQDs). The proposed doping approach can provide a vehicle to tune the photoluminescence intensity and negative photoconductivity in GOQDs for promising applications in optoelectronics.

JTu2A.113
Grating-patterned Perovskite Light Emitting Diodes for Enhanced Performance, Chen Zou[1], Lih Y. Lin[1]; [1]*Univ. of Washington Seattle, USA.* We introduce grating patterns into perovskite films using a simple soft lithography method with common DVD discs as templates. The patterned perovskite films exhibit enhanced photoluminescence and the performance of light emitting diodes is improved.

JTu2A.114
Photothermal Mirror Z-Scan, Aristides Marcano Olaizola[1]; [1]*Delaware State Univ., USA.* This work describes a pump-probe photothermal mirror Z-scan experiment aimed at determination of thermal diffusivity, thermoelastic coefficient, and quantum yield of thermal heating of the surface of transparent and non- transparent solid samples including films.

JTu2A.115
Nearly Color-shift Free Full-color Monolithic Hybrid Quantum Dots Semipolar Micro Light-emitting Diodes Display, Sung-Wen Huang Chen[1], Lee-Feng Chen[1], Tingzhu Wu[2,1], Chun-Fu Lee[1], Po-Tsung Lee[1], Hao-Chung Kuo[1]; [1]*National Chiao Tung Univ., Taiwan;* [2]*Xiamen Univ., China.* Full-color displays demonstrate by the semipolar blue micro-light-emitting diodes array and quantum dots color-conversion layer. This display shows a wide color gamut and color stability since reduced quantum confined Stark effect by the semipolar substrate.

JTu2A.116
Energy Transfer in Transition Metal Ions co-Doped Chalcogenide Mid-IR Laser Materials, Vladimir Fedorov[1,2], Tristan Clarlson[1], Sergey Mirov[1,2]; [1]*Univ. of Alabama at Birmingham, USA;* [2]*IPG Photonics, USA.* We reveal energy transfer between chromium-iron and cobalt-iron ions in co-doped II-VI chalcogenide laser materials with a rate faster than 300 ns, which is attractive for development of effective mid-IR lasers operating over 3.5-6.0 mm.

11:30–13:00 JTu2A • Poster Session I and Lunch

JTu2A.117
Radical mitigation of photo-darkening effect in Yb-doped fiber through deuterium treatment, Jiaming Li[1], Nan Zhao[1]; *[1]South China Normal Univ., China.* We report radical mitigation of photo-darkening effect in Yb-doped fibers with deuterium. After deuterium loading, the fiber did not exhibit any PD effect. Existed color centers induced by PD could also be eliminated by deuterium.

JTu2A.118
Hydrogen plasma treatment of MoS_2 with graphene protection, Anishkumar Soman[1], Robert A. Burke[3], Qui Li[1], Michael Valentin[2], Eugene Zakar[3], Ugochukwu Nsofor[1], Steven Hegedus[1], Ujjwal Das[4], Jianping Shi[5], Yanfeng Zhang[5], Tingyi Gu[1]; *[1]Univ. of Delaware, USA; [2]Univ. of California – Riverside, USA; [3]US Army Research Lab, USA; [4]Inst. of Energy Conversion, USA; [5]Peking Univ., China.* Hydrogen plasma treatment can create defects such as sulfur vacancies in single layer MoS_2. A single layer graphene's protection can effectively reduce the defects formation as confirmed by Raman spectroscopy.

JTu2A.119
Synthesis, Spectroscopy and Efficient Laser Operation of Tm:$Lu_3Al_5O_{12}$ Transparent Ceramics, Josep Serres[2], Pavel Loiko[3], Venkatesan Jambunathan[4], Xavier Mateos[2], Yicheng Wang[1], Jiang Li[5], Liza Basyrova[3], Antonio Lucianetti[4], Tomas Mocek[4], Magdalena Aguilo[2], Francesc Diaz[2], Uwe Griebner[1], Valentin Petrov[1]; *[1]Max Born Inst., Germany; [2]Universitat Rovira i Virgili, Spain; [3]ITMO Univ., Russia; [4]HiLASE, Czechia; [5]Shanghai Inst. of Ceramics, China.* Tm:$Lu_3Al_5O_{12}$ ceramics are synthesized by solid-state reactive sintering, and their structure and spectroscopic properties are studied. A Tm:$Lu_3Al_5O_{12}$ ceramic laser diode-pumped at 793 nm generates 3.12 W at ~2.02 μm with a slope efficiency of 60.2%.

JTu2A.120
Remote Photonic Sensing of Cerebral Hemodynamics via Spatial-Temporal Analysis of Back-Scattered Laser Light, Nisan Ozana[1], Adam Noah[2], Xian Zhang[2], Yumie Ono[2,3], Joy Hirsch[2], Zeev Zalevsky[1]; *[1]Bar Ilan Univ., Israel; [2]Yale Univ., USA; [3]Meiji Univ., Japan.* The ability to remotely extract cerebral hemodynamics from specific locations on the brain using time varied speckle patterns is innovative. The first step towards remote sensing of brain activity and stroke is presented.

JTu2A.121
Effectively enhancing photon-exciton coupling via a gap whispering gallery modes, Qi Zhang[1], Juanjuan Ren[1], Xueke Duan[1], He Hao[1], Qihuang Gong[1], Ying Gu[1]; *[1]Peking Univ., China.* We theoretically demonstrate the coupling coefficient enhancement in cavity quantum electrodynamics system via a nanogap between a dielectric nanotoroid and a dielectric nanowire.

JTu2A.122
Efficiently Loading Cold Atomic Ensemble into an Optical Cavity with High Optical Depth, Yue Jiang[1], Yefeng Mei[1], Yueyang Zou[1], Ying Zuo[1], Shengwang Du[1]; *[1]The Hong Kong Univ. of Sci&Tech, Hong Kong.* We describe a cold atom apparatus for achieving high optical depth (OD) and OD-duty cycle product by loading a dark-line 2D MOT into an optical cavity. Cavity enhanced OD can go up to 7600, with 188 times enhancement of the single-pass OD, and highest OD-duty cycle product is 1697.

JTu2A.123
Quantum-correlated Light Source from Dual-seeded Four-wave Mixing with a Diode Laser System, Meng-Chang Wu[3], Nicholas R. Brewer[3,1], Rory W. Speirs[3], Bonnie L. Schmittberger[3], Kevin M. Jones[2], Paul D. Lett[3,1]; *[1]National Inst. of Standards and Technology, USA; [2]Williams College, USA; [3]Univ. of Maryland, College Park, USA.* We have obtained broadband intensity-difference squeezing from sub 10 Hz to 20 MHz via four-wave mixing (4WM) in a rubidium vapor. This was accomplished by dual-seeding the 4WM process and using semiconductor diode lasers.

JTu2A.124
Machine Learning Applied in Reconstruction of Unitary Matrix for Quantum Computation, Hui Zhang[1], Hong Cai[4], Stefano Paesani[2], Raffaele Santagati[2], Anthony Laing[2], Leong Chuan Kwek[3], Ai Qun Liu[1]; *[1]Nanyang Technological Univ., Singapore; [2]Univ. of Bristol, UK; [3]National Univ. of Singapore, Singapore; [4]Inst. Of Microelectronics, Singapore.* Optimal method are applied in characterizing and reconstructing designed unitary matrices on linear optical circuit. The scheme is based on the measurement of single-photon and two-photon statistics using coherent beams.

NOTES

Executive Ballroom 210A

Joint

13:00–15:00
JTu3A • Symposium on Quantum Information in Time-Frequency Domain I
Presider: To Be Announced

JTu3A.1 • 13:00 Invited
Tailored Generation, Manipulation, and Application of Photonic Temporal Modes, Benjamin Brecht[1], Jano G. Lopez[1], Markus Allgaier[1], Vahid Ansari[1], John M. Donohue[1,2], Christine Silberhorn[1]; [1]*Paderborn Univ., Germany;* [2]*Inst. for Quantum Computing, Canada.* Pulsed temporal modes form a high-dimensional basis for quantum information applications. By controlling these modes, we can tailor quantum states and measurements for applications such as quantum state tomography or quantum metrology.

JTu3A.2 • 13:30
Spectro-Temporal Asymmetry in Optical Parametric Processes, Usman A. Javid[1], Steven D. Rogers[1], Austin Graf[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA.* We have, for the first time, generated bi-photon quantum states of light with temporal waveforms showing stunning asymmetry and exotic coherence properties using cavity-enhanced four wave mixing in an optical mircoresonator with selectively split modes.

JTu3A.3 • 13:45
A two-qudit operation on a 256-dimensional Hilbert space, Poolad Imany[1], Mohammed S. Alshaykh[1], Joseph M. Lukens[2], Jose A. Jaramillo-VIllegas[3], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]*Purdue Univ., USA;* [2]*Oak Ridge National Lab, USA;* [3]*Universidad Tecnológica de Pereira, Colombia.* By encoding two 16-dimensional qudits in the time and frequency degrees of freedom of a heralded single photon, we realize a deterministic photonic two-qudit SUM gate operating on a 256-dimensional Hilbert space.

JTu3A.4 • 14:00 Invited
Full Single and Two Photon Spectral Mode-function Reconstruction, Valérian Thiel[1], Alex O. Davis[1,2], Brian J. Smith[3,1]; [1]*Univ. of Oxford, UK;* [2]*Sorbonne Université, France;* [3]*Univ. of Oregon, USA.* We present a novel method to reconstruct the full spectral-temporal mode function of a single photon state. The setup combines spectral sheering interferometry with high resolution spectrometers and is self-referenced. We show that this method can be applied to the full characterization of a photon pair, recovering phase correlations and time/frequency entanglement.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

13:00–15:00
FTu3B • PT Symmetry & Exceptional Points
Presider: To Be Announced

FTu3B.1 • 13:00 Invited
An On-chip Optical Brillouin Gyroscope with Earth-Rotation-Rate Sensitivity , Kerry J. Vahala[1], Yu-Hung Lai[1], Myoung-Gyun Suh[1]; [1]*California Inst. of Technology, USA.* A chip-based gyroscope is demonstrated that uses counter-propagating Brillouin lasers to measure rotation as a Sagnac-induced frequency shift. Demonstration of rotation measurement below the Earth rotation rate is presented. Prospects for improved performance are discussed.

FTu3B.2 • 13:30
Bimodal Directional Laser via Dynamically Encircling an Exceptional Point, Jason Leshin[1], Yousef Alahmadi[1], Absar U. Hassan[1], Gisela Lopez Galmiche[1], Patrick LiKamWa[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*Univ. of Central Florida, USA.* We demonstrate dynamical encirclement of an exceptional point in a laser cavity. By continuously varying the detuning and coupling between a pair of PT-symmetric waveguides, the laser simultaneously emits two eigenmodes, one from each facet.

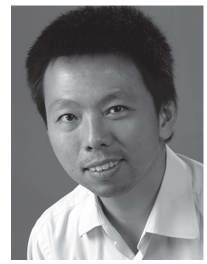
FTu3B.3 • 13:45
Measurement of photon correlations in PT symmetric systems, Friederike Klauck[1], Lucas Teuber[1], Marco Ornigotti[1], Matthias Heinrich[1], Stefan Scheel[1], Alexander Szameit[1]; [1]*Inst. of Physics, Universität Rostock, Germany.* We investigate quantum interference in a PT-symmetric system by measuring a Hong-Ou-Mandel-Dip in waveguide couplers. The nontrivial loss distribution giving rise to PT-symmetry systematically displaces photon bunching with respect to the Hermitian case.

FTu3B.4 • 14:00
Pulse shortening in two coupled rings under amplitude modulations with parity-time symmetry, Luqi Yuan[1,2], Qian Lin[2], Meng Xiao[2], Avik Dutt[2], Shanhui Fan[2]; [1]*Shanghai Jiao Tong Univ., China;* [2]*Stanford Univ., USA.* We show pulse shortening in two coupled rings under amplitude modulations, where the modulation phases have a π phase difference. The system exhibits parity-time symmetry, and its importance is highlighted in pulsed laser systems.

Executive Ballroom 210C

13:00–15:00
FTu3C • Polaritonic Interactions in Transition Metal Dichalcogenide
Presider: Esther Wertz, Rensselaer Polytechnic Institute, USA

FTu3C.1 • 13:00 Tutorial
Optical Spectroscopy of Transition Metal Dichalcogenide Monolayers and Heterostructures, Feng Wang[1,2]; [1]*Univ. of California Berkeley, USA;* [2]*Materials Science Division, LBNL, USA.* In this tutorial, I will describe a variety of optical techniques that can be used to probe the unique exciton and valley physics and their ultrafast dynamics in transition metal dichalcogenides monolayers and heterostructures.



Feng Wang is an professor of physics at the university of California, Berkeley and faculty scientist at the Lawrence Berkeley National Lab. His research interests have been in ultrafast nano-optics, with special focus on low dimensional materials, including one dimensional carbon nanotubes and two-dimensional graphene and transition metal dichalcogenides.

FTu3C.2 • 14:00
Composite photonic platform based on 2D semiconductor monolayers, Ipshita Datta[1], Sang Hoon Chae[1], Gaurang R. Bhatt[1], Baichang Li[1], Yiling Yu[2], Chibeom Park[3], Jiwoong Park[3], Linyou Cao[2], D. N. Basov[1], James Hone[1], Michal Lipson[1]; [1]*Columbia Univ., USA;* [2]*Dept. of Material Science and Engineering, North Carolina State Univ., USA;* [3]*Univ. of Chicago, USA.* We demonstrate phase modulation in the near infrared (1450 - 1650 nm) by electrostatically doping 2D semiconductor monolayers integrated on SiN waveguides. We show a $V_\pi L$ of 1.4 V.cm and 0.8 V.cm for MoS_2 and WS_2, respectively.

CLEO: QELS-Fundamental Science

13:00–15:00
FTu3D • Tailored Light-Matter Interactions
Presider: To Be Announced

FTu3D.1 • 13:00
Observation of Branched Flow of light, Anatoly Patsyk[1], Miguel Bandres[1], Mordechai Segev[1], Uri Sivan[1]; [1]*Technion-Israel Inst. of Technology, Israel.* We present the first study of optical branched flow. As light propagates in thin dielectric films it experiences scattering from inhomogeneities, forming bundles displaying the features and statistics of the phenomenon known as branched flow.

FTu3D.2 • 13:30
Ballistic Metamaterials., Evgenii E. Narimanov[1]; [1]*Purdue Univ., USA.* Ballistic metamaterials, metal-dielectric composites with the unit cell size smaller than electron mean free path, represent a new class of composite media with many unique properties, such as hyperbolic response above the plasma frequency.

FTu3D.3 • 13:45
Fundamental figure of merit for engineering dipole-dipole interactions, Cristian L. Cortes[1], Ward D. Newman[1], Ashwin K. Boddeti[1], Tyler Sentz[1], Zubin Jacob[1]; [1]*Purdue Univ., USA.* Over the last decade there has been a debate regarding the role of the photonic environment in enhancing, inhibiting and imparting coherence to dipole-dipole interactions. We develop a unified figure of merit to conclusively explain multiple recent experiments.

FTu3D.4 • 14:00
Light-Matter Interaction in Disordered Metal-Dielectric Environments, Sangeeta Rout[1], Monika Biener[2], Zhen Qi[2], Carl Bonner[1], T Shahbazyan[3], M Noginov[1]; [1]*Norfolk State Univ., USA;* [2]*Lawrence Livermore National Lab, USA;* [3]*Dept. of Physics, Atmospheric Sciences & Geoscience, Jackson State Univ., USA.* We studied emission kinetics of HITC dye in disordered metal-dielectric environments and found that the latter, contrary to expectations, can reverse emission kinetics shortening in highly concentrated dyes, caused by a combination of relaxation processes.

CLEO: Science & Innovations

13:00–15:00
STu3E • High Peak-Power Lasers & Technologies I
Presider: Jake Bromage Univ. of Rochester, USA

STu3E.1 • 13:00
Optimization of wavefront aberration for Shanghai Super-intense Ultrafast Laser Facility by double deformable mirrors, Lianghong Yu[1], Zhen Guo[1], Xiaoyan Liang[1], Ruxin Li[1]; [1]*Shanghai Inst Optics & Fine Mech, CAS, China.* A peak intensity of 10^{22}W/cm^2 was achieved with an f/2.5 off-axis parabolic (OAP) mirror after the wavefront aberration being optimized by double deformable mirrors in the Shanghai super-intense ultrafast laser facility (SULF).

STu3E.2 • 13:15
Generation of the Ultraintense Laser Pulse with an Intensity of 6×10^{22} W/cm^2, JW Yoon[2,1], Seong Ku Lee[2,1], Jae Hee Sung[2,1], Hwang Woon Lee[2], Cheonha Jeon[2], Il Woo Choi[2,1], Junghoon Shin[2], Hyung Taek Kim[2,1], Bjorn M. Hegelich[2,3], Chang Hee Nam[2,3]; [1]*Advanced Photonics Research Inst., Gwangju Inst. of Science and Technology, South Korea (the Republic of);* [2]*Center for Relativistic Laser Science, Inst. for Basic Science, South Korea (the Republic of);* [3]*Dept. of Physics and Photon Science, Gwangju Inst. of Science and Technology, South Korea (the Republic of).* Wavefront correction of the PW laser system at IBS-GIST was performed using deformable mirrors. The PW laser beam was focused by an f/1.6 OAP. The peak intensity is 6×10^{22} W/cm^2, the highest intensity ever reached.

STu3E.3 • 13:30 Tutorial
Optical Interference Coatings for High Performance Lasers, Carmen S. Menoni[1]; [1]*Colorado State Univ., USA.* This tutorial will cover the fundamentals of optical interference coatings (IC) design, growth and characterization. It will also review mechanisms of near infrared laser damage and discuss state-of-the-art ICs performance in chirped pulse amplification laser systems.

Carmen S. Menoni is a University Distinguished Professor at Colorado State University in the department of Electrical and Computer Engineering. She directs the Advanced Thin Film Laboratory dedicated to the growth and characterization of thin film oxides for the engineering of interference coatings for high-power lasers and ultrahigh precision optics for gravitational wave interferometers. Her group also specializes in the usage of bright coherent beams of extreme ultraviolet laser light of wavelengths between 10 and 50 nm for optics applications such as nanoscale imaging, ablation and mass spectrometry. Her work is published in over 200 refereed publications and numerous invited and contributed conference presentations. Prof. Menoni was elected Fellow of the IEEE, OSA, APS, AAAS and of SPIE, and received an IEEE Photonics Society Distinguished Lecture Award. Prof. Menoni is President-Elect of the IEEE Photonics Society.

13:00–15:00
STu3F • Terahertz Sensing & Devices
Presider: James Lloyd-Hughes, Univ. of Warwick, UK

STu3F.1 • 13:00 Invited
Recent Advances in THz Scanning Tunneling Microscopy, Vedran Jelic[1,2], Yang Luo[1], Jesus Calzada[1], Peter Nguyen[1], Daniel Mildenberger[1], Tianwu Wang[1], Frank Hegmann[1]; [1]*Physics, Univ. of Alberta, Canada;* [2]*Physics and Astronomy, Michigan State Univ., USA.* Terahertz scanning tunneling microscopy (THz-STM) is a newly developed technique that can probe the ultrafast dynamics of surfaces with single atom resolution. We use THz-STM to explore the subpicosecond tunneling dynamics of a photoexcited semiconductor surface.

STu3F.2 • 13:30
Biomolecule sensing using low energy terahertz photons exploiting nano-slot resonance and two-dimensional materials, Sang-Hun Lee[1], Jong-Ho Choe[2], Chulki Kim[1], Minah Seo[1]; [1]*Sensor system research center, South Korea Inst. of Science and Technology, South Korea (the Republic of);* [2]*Physics Dept., South Korea Univ., South Korea (the Republic of).* We performed terahertz time-domain spectroscopy for discrimination of biomolecules using absorption enhancement on a graphene-hybridized nano-slot device. The terahertz sensing device shows noticeable signal change with different trends for different nucleotides even in femto-mole level.

STu3F.3 • 13:45
Filling the 5-10 THz Gap Using Ge-based Photoconductive Emitter, Abhishek Singh[1], Alexej Pashkin[1], Stephan Winnerl[1], Manfred Helm[1,2], Harald Schneider[1]; [1]*Helmholtz Zentrum Dresden-Rossendorf, Germany;* [2]*Cfaed and Inst. of Applied Physics, TU Dresden, Germany.* Generating a continuous spectrum covering the 5-10 THz range is difficult due to strong THz absorption in polar materials. We demonstrate that a photoconductive emitter based on non-polar germanium is able to achieve this goal.

STu3F.4 • 14:00
High-Responsivity and Broadband Photoconductive Terahertz Detection via Photon Trapping, Nezih Yardimci[1], Deniz Turan[1], Semih Cakmakyapan[1], Mona Jarrahi[1]; [1]*Univ. of California - Los Angeles, USA.* We present a photoconductive terahertz detector, which utilizes photon trapping to offer broadband terahertz detection, over a 0.1-4.5 THz band, with large dynamic ranges, exceeding 100 dB, without using a short-carrier-lifetime semiconductor substrate.

Tuesday, 13:00–15:00

Executive Ballroom 210G

Joint

13:00–15:00
JTu3G • Symposium on Space-borne Quantum Sensors

JTu3G.1 • 13:00 Invited
Atom Interferometry for Space-Borne Sensors, Sergio Mottini[1], Stefano Cesare[1], Alberto Anselmi[1], Linda Mondin[2], Olivier Carraz[2], Federica Migliaccio[3], Mirko Reguzzoni[3], Fiodor Sorrentino[5], Khulan Batsukh[3], Guglielmo Tino[4]; [1]*Thales Alenia Space Italia SpA, Italy;* [2]*European Space Agency, Netherlands;* [3]*Politecnico di Milano, Italy;* [4]*INFN-Fi, Italy;* [5]*INFN - Ge, Italy.* The perspectives for application of atom interferometry in inertial navigation, geophysics, or tests of fundamental physics motivate the interest for the development of space-borne quantum accelerometers and gradiometers. Technical challenges and implementation examples are presented.

JTu3G.2 • 13:30 Invited
Enabling Technologies for Space-Based Quantum Systems, Evan A. Salim[1]; [1]*ColdQuanta, Inc, USA.* Quantum technologies have great potential to enable space-based applications of information science, sensing, navigation, and timekeeping. We present enabling technologies to address the technical challenges of preparing cold atom based systems for use in space.

JTu3G.3 • 14:00 Invited
The Coolest Spot in the Universe: Early results from the Cold Atom Lboratory Mission Aboard the International Space Station, Robert J. Thompson[1]; [1]*Jet Propulsion Lab, USA.* The Cold Atom Lab launched to the International Space Station in May 2018, and has been operating since then as the world's first multi-user facility for the study of ultra-cold atoms in microgravity. In this talk, I present early results from the Cold Atom Lab (CAL).

Executive Ballroom 210H

CLEO: Science & Innovations

13:00–15:00
STu3H • Biophotonics & Optofluidics
Presider: Jessica Houston New Mexico State Univ., USA

STu3H.1 • 13:00
An Optofluidic Tweeze-and-Drag Cell Stretcher in a Microfluidic Channel, Zhanshi Yao[1], Ching Chi Kwan[1], Andrew W. Poon[1]; [1]*Hong Kong Univ. of Sci. and Tech., Hong Kong.* We report an optofluidic tweeze-and-drag cell stretcher in a microfluidic channel. We distinguish healthy and glutaraldehyde-treated rabbit red blood cells based on their different mechanical deformations at a cell-stretching throughput of ~1.2 cells/s.

STu3H.2 • 13:15
Optofluidic Platform with Integrated Optical Waveguides and Sample Preparation for Digitized Detection of Nucleic Acid Targets, Aadhar Jain[1], Gopikrishnan G. Meena[1], Alexandra Stambaugh[1], Jean Patterson[3], Aaron Hawkins[2], Holger Schmidt[1]; [1]*Univ. of California, Santa Cruz, USA;* [2]*Brigham Young Univ., USA;* [3]*Texas Biomedical Research Inst., USA.* An architecture of sensitive solid-core and liquid-core optical waveguides are integrated with a pneumatic valve array on a single optofluidic platform to enable specific capture, labeling and detection of single nucleic acid strands using barcode fluorescence reporters.

STu3H.3 • 13:30
Bend-Insensitive Through-Fiber Stimulated Emission Depletion (STED) Imaging of HeLa Cells, Brendan M. Heffernan[1], Stephanie A. Meyer[2], Diego Restrepo[3], Mark Siemens[4], Emily A. Gibson[2], Juliet T. Gopinath[1]; [1]*Univ. of Colorado, Boulder, USA;* [2]*Bioengineering, Univ. of Colorado Anschutz Medical Campus, USA;* [3]*Cell Biology, Univ. of Colorado Anschutz Medical Campus, USA;* [4]*Physics and Astronomy, Univ. of Denver, USA.* We demonstrate, for the first time, STED images of biological samples where fluorescence has been collected through the same fiber used to transport excitation and depletion light (through-fiber imaging). We also quantitatively demonstrate fiber-bending-independent resolution.

STu3H.4 • 13:45
Single Particle Detection Enhancement with Wavelet-based Signal Processing Technique, Vahid Ganjalizadeh[1], Gopikrishnan G. Meena[1], Matthew Stott[2], Holger Schmidt[1], Aaron Hawkins[2]; [1]*ECE, Univ. of California, Santa Cruz, USA;* [2]*Electrical and Computer Engineering, Brigham Young Univ., USA.* Chip-based single molecule detection requires ultra-sensitive devices and robust signal processing methods. A new wavelet-based signal processing method is introduced that improves detection and error rates on an optofluidic platform by 2x and 3x, respectively.

STu3H.5 • 14:00 Tutorial
Wavefront Shaping – the Threading of Light Through Scattering Media, Changhuei Yang[1]; [1]*California Inst. of Technology, USA.* Wavefront shaping has been an active research area over the past decade. Its ability to control light transmission through or into a scattering medium has significant biophotonics, computation, imaging, encryption and other applications. In this tutorial, I will go through the various optical concepts involved in wavefront shaping – feedback iteration, phase conjugation, optical memory effect, guidestar strategies, speckle correlations, etc. I will also survey the use of wavefront shaping in biophotonics. Finally, I will also examine two recent and surprising developments in wavefront shaping. The first is the intentional combination of wavefront shaping and a controlled scattering medium to create novel optical system – in effect, turning scattering from a 'foe' to a 'friend' for wavefront shaping. The second is the complete dropping of phase characterization in a new class of 'wavefront shaping' methods.

continued on page 116

Meeting Room 211 A/B

CLEO: Applications & Technology

13:00–15:00
ATu3I • Ultrafast Laser Processing
Presider: Dirk Mueller; Coherent Inc., USA

ATu3I.1 • 13:00 Invited
Glass Machining and In-situ Metrology: Recovery of Spatio-Temporal Phase Distribution From 2-Dimensional Interference Fringe Movement Caused by Irradiation of Glass with Ultra-Short Laser Pulses at High Pulse Repetition Rates, Kristian Cvecek[1,2], Johannes Heberle[1,2], Michael Bergler[1,3], Isamu Miyamoto[2,4], Dominique De Ligny[3], Michael Schmidt[1,2]; [1]*Inst. of Photonic Technologies, Friedrich-Alexander-Univ. of Erlangen-Nürnberg, Germany;* [2]*Graduate School in Advanced Optical Technologies, Friedrich-Alexander-Univ. of Erlangen-Nürnberg, Germany;* [3]*Inst. of Glass and Ceramics, Friedrich-Alexander-Univ. of Erlangen-Nürnberg, Germany;* [4]*Osaka Univ., Japan.* An interferometry-based method for direct observation of phase modifications caused by transient temperature and pressure changes during irradiation of glass using ultra-short laser pulses is shown. The method provides a 3-dimensional time-resolved phase distribution and allows to distinguish between reversible and irreversible laser induced phase changes inside the glass.

ATu3I.2 • 13:30
Femtosecond Laser Polishing of Germanium Towards Fabrication of Freeform Optics, Lauren L. Taylor[1], Jing Xu[2], Michael Pomerantz[2], Thomas R. Smith[3], John C. Lambropoulos[2], Jie Qiao[1]; [1]*Rochester Inst. of Technology, USA;* [2]*Univ. of Rochester, USA;* [3]*Aperture Optical Sciences, USA.* A modeling tool and a scanning strategy for polishing germanium using femtosecond lasers are devised. Controllable material removal and sub-nanometer surface roughness are demonstrated, opening the path towards ultrafast laser polishing of freeform optics.

ATu3I.3 • 13:45
A Comparative Study of Surface Modification effects of Femtosecond and Nanosecond Laser on CVD Diamond Tools during Sharpening Processing, Xiaoxu Liu[1], Kohei Natsume[1], Satoru Maegawa[1], Fumihiro Itoigawa[1], Shingo Ono[1]; [1]*Nagoya Inst. of Technology, Japan.* In this study sharpening processing with femtosecond laser was innovatively performed on CVD diamond tools. Furthermore, surface modification effects of femtosecond and nanosecond laser in sharpening processing on CVD diamond were compared with Raman spectroscopy.

ATu3I.4 • 14:00
Surface modification of polycrystalline CVD diamond films with femtosecond laser, Kohei Natsume[1], Xiaoxu Liu[1], Satoru Maegawa[1], Fumihiro Itoigawa[1], Shingo Ono[1], Michiharu Ota[2]; [1]*Nagoya Inst. of Technology, Japan;* [2]*IMRA America, USA.* The surface modification of CVD diamond irradiated with femtosecond laser of different fluences has been studied and analyzed with Raman spectroscopy. Through comparing with DLC coating processed equally, this improved crystallinity mechanism has been discussed.

Meeting Room 211 C/D

CLEO: Science & Innovations

13:00–15:00
STu3J • Kerr Frequency Microcombs
Presider: Brandon Shaw; Naval Research Lab, USA

STu3J.1 • 13:00 Tutorial
Novel Material Platforms for Resonator Kerr Combs, Andrea M. Armani[1]; [1]*Univ. of Southern California, USA.* Resonators are an emerging platform for generating Kerr combs. By attaching a range of different nanomaterials to the surface of optical resonators, we demonstrate a new approaches for fabricating high performance frequency combs.

Andrea Armani received her BA in physics from the University of Chicago and her PhD in applied physics from Caltech. She is currently the Ray Irani Chair in Engineering and Materials Science at the University of Southern California. She is also the Director of the W. M. Keck Photonics Cleanroom as well as the soon to open John D. O'Brien Nanofabrication Laboratory, two core nanofabrication cleanrooms at USC.

STu3J.2 • 14:00
Integrated Si3N4 Soliton Microcomb Driven by a Compact Ultra-low-noise Laser, Arslan Raja[3], Junqiu Liu[3], Nicolas Volet[1], Rui Ning Wang[3], Jijun He[3], Erwan Lucas[3], Romain Bouchand[3], Paul Morton[2], John Bowers[1], Tobias J. Kippenberg[3]; [1]*Univ. of California, Santa Barbara (UCSB), USA;* [2]*Morton Photonics, USA;* [3]*École Polytechnique Fédérale de Lausanne, Switzerland.* We generate 100-GHz soliton microcombs in a photonic integrated high-Q Si3N4 microresonator using an ultra-compact, high-power and low-frequency-noise semiconductor-based laser. The soliton is initiated via direct current tuning of the laser.

Meeting Room 212 A/B

CLEO: Applications & Technology

13:00–15:00
ATu3K • Biophotonic Spectroscopy
Presider: Ilko K. Ilev; U.S. Food and Drug Administration, USA

ATu3K.1 • 13:00
Femtosecond Laser Micromachining in Ophthalmic Hydrogels: Micro-Raman Spectroscopy of Materials Effects, Dan Yu[1], Ruiting Huang[1], Wayne H. Knox[1]; [1]*Univ. of Rochester, USA.* A one-layer dense line pattern was inscribed into ophthalmic hydrogels using a 405 nm, 8.3 MHz laser. The local microstructural changes, especially the water content, were examined using confocal Raman spectroscopy.

ATu3K.2 • 13:15
Mid-infrared Photothermal Imaging of Fibroblast Cells, Panagis Samolis[1], Michelle Y. Sander[1]; [1]*Boston Univ., USA.* Label-free vibrational mid-infrared photothermal amplitude and phase images of fixed fibroblast cells in a collagen extracellular matrix are presented, providing complementary insights into optical material and thermal diffusion properties.

ATu3K.3 • 13:30
High-speed, high-sensitivity spectroscopic stimulated Raman scattering microscopy by ultrafast delay-line tuning and deep learning, Haonan Lin[1], Fengyuan Deng[1], Kai-Chih Huang[1], Hyeon Jeong Lee[1], Ji-Xin Cheng[1]; [1]*Boston Univ., USA.* We present a stimulated Raman scattering imaging system which acquires a Raman spectrum within 20 µs. A U-Net deep learning network is applied to maintain the sensitivity at high speeds, enabling high-throughput label-free spectroscopic imaging of cells and tissues.

ATu3K.4 • 14:00
Doppler Detection of Pathogenic Activity in Living Tissue by Biodynamic Imaging, Honggu Choi[1], Jessica Zuponcic[1], Eduardo Ximenes[1], Michael Ladisch[1], John Turek[1], David D. Nolte[1]; [1]*Purdue Univ., USA.* Bacterial infection of living tissue is monitored by biodynamic imaging based on intracellular Doppler fluctuation spectroscopy. The efficacy of pathogen suppression by antibiotics may enable detection of antibiotic resistant strains *in vitro*.

Meeting Room 212 C/D

CLEO: Science & Innovations

13:00–15:00
STu3L • Mode-Locked Fiber Lasers I
Presider: Camille-Sophie Bres; Ecole Polytechnique Federale de Lausanne, Switzerland

STu3L.1 • 13:00
Generation of 17 fs pulses form a Mamyshev oscillator with intra-cavity photonic crystal fiber, Chunyang Ma[2,1], Ankita Khanolkar[1], Yimin Zang[1], Andy Chong[1]; [1]*Univ. of Dayton, USA;* [2]*Jilin Univ., China.* A few cycle pulses (~5 cycles) with broad spectrum (~400 nm) are generated from a Mamyshev oscillator. Such a broad spectrum can be stabilized in the cavity by a self-similar attractor in the gain fiber.

STu3L.2 • 13:30
Femtosecond pulses generated from a compact all-polarization-maintaining (PM) Ytterbium-doped fiber laser, Wu Zhichao[1,2], Yujun Feng[2], SongNian Fu[1], Ming Tang[1], Deming Liu[1], Jonathan Price[2], Johan Nilsson[2]; [1]*Huazhong Univ of Science and Technology, China;* [2]*Univ. of Southampton, UK.* We demonstrate femtosecond dissipative solitons generated from an all-PM Ytterbium-doped fiber laser. The simplified fiber ring cavity has been shown to reliably self-start and provides a route to a robust platform for future development.

STu3L.3 • 13:45
All-Polarization-Maintaining, Polarization-Multiplexed Mode-Locked Er-Fiber Laser with Nonlinear Amplifying Loop Mirror, Yoshiaki Nakajima[1,2], Yuya Hata[1,2], Yugo Kusumi[1], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan.* We demonstrate an all-polarization-maintaining, polarization-multiplexed mode-locked Er-fiber laser with nonlinear amplifying loop mirror that generates two mutually coherent frequency combs with slightly different repetition rates at same center wavelength without nonlinear spectral broadening.

STu3L.4 • 14:00
Dispersion Management of Polarization Maintaining Er-doped Figure 9 Ultrashort Pulse Fiber Laser, Hayato Suga[1], Masahito Yamanaka[1], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan.* We investigated dispersion management of polarization maintaining Er-doped, figure 9 fiber laser both experimentally and numerically. A 132 fs ultrashort pulse with spectral width of 46 nm was achived around zero dispersion region.

Marriott Salon I & II

Marriott Salon III

Marriott Salon IV

Joint

CLEO: Science & Innovations

13:00–15:00
JTu3M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials I
Presider: To Be Announced

JTu3M.1 • 13:00 Invited

Extreme Nonlinear Optics With Dielectric Metasurfaces, Igal Brener[1]; [1]*Sandia National Labs Livermore, USA.* We have used dielectric metasurfaces made from direct bandgap semiconductors to generate high harmonics and nonlinear mixing simultaneously, without the need of phase matching. Inclusion of broken-symmetry designs and quantum heterostructures can lead to even higher efficiency.

JTu3M.2 • 13:30 Invited

Enhancement of Nonlinear Processes by Surface Plasmons, Pierre Berini[1]; [1]*Univ. of Ottawa, Canada.* Nonlinear processes using nanoscale metallic structures are of strong interest due to their ability to enhance local fields and engineer the optical density of states. We discuss various nonlinear processes that exploit these effects.

JTu3M.3 • 14:00

Coherent Control of the Non-instantaneous Response of Plasmonic Nanostructes, Eyal Bahar[3,2], Uri Arieli[3,1], Haim Suchowski[3,1]; [1]*Condest Matter Physics., Tel Aviv Univ., Faculty of Exact Sciences, Israel;* [2]*Condenst Matter Physics., Faculty of Exact Sciences, Tel Aviv Univ.., Israel;* [3]*The Center for Light-Matter Interaction, Faculty of Exact Sciences, Tel Aviv Univ., Israel.* We experimentally demonstrate coherent control of the nonlinear response of resonant nanostructures beyond the weak-field regime. Furthermore, we develop a novel theoretical approach capturing the induced nonlinearities of shaped ultrafast pulses with resonant nanostructured media.

13:00–15:00
STu3N • Lasers on Silicon & Nanolasers
Presider: Kei May LAU, Hong Kong University of Science and Technology, Hong Kong

STu3N.1 • 13:00

Triple reduction of threshold current for 1.3 µm InAs quantum dot lasers on patterned, on-axis (001) Si, Chen Shang[1], Yating Wan[1], Justin Norman[1], Daehwan Jung[1], Qiang Li[2], Kei May Lau[2], Arthur Gossard[1], John Bowers[1]; [1]*Univ. of California Santa Barbara, USA;* [2]*Hong Kong Univ. of Science and Technology, Hong Kong.* Triple reduction of threshold current was achieved for 1.3 µm InAs quantum dot lasers on patterned, on-axis (001) Si. This was enabled by reducing the threading dislocation density, from $7x10^7$ to $3x10^6$ cm^{-2}.

STu3N.2 • 13:15

Tunable III-V-on-Si Laser with Resonant Photonic Molecule Mirrors, Guilherme F. de Rezende[1,2], Newton Frateschi[1], Gunther Roelkens[2]; [1]*"Gleb Wataghin" Physics Inst., Universidade Estadual de Campinas, Brazil;* [2]*Photonics Research Group, INTEC, Ghent Univ.-imec, Belgium.* We propose, fabricate and characterize a novel III-V-on-Si laser. Resonant mirrors are realized by tailoring supermodes of coupled microrings. A threshold of 40mA, series resistance of 10 Ω and SMSR of 40dB is reported.

STu3N.3 • 13:30

Investigation of SiGeSn/GeSn/SiGeSn Quantum Well Structures and Optically Pumped Lasers on Si, Yiyin Zhou[1,2], Joe Margetis[4], Grey Abernathy[1,2], Wei Dou[1], Perry Grant[1,2], Bader Alharthi[1], Wei Du[5], Alicia Wadsworth[6], Qianying Guo[6], Huong Tran[1,3], Solomon Ojo[1,2], Aboozar Mosleh[7], Seyed Ghetmiri[7], Gregory Thompson[6], Jifeng Liu[8], Greg Sun[9], Richard Soref[9], John Tolle[4], Baohua Li[3], Mansour Mortazavi[7], Shui-Qing Yu[1]; [1]*Dept. of Electrical Engineering, Univ. of Arkansas, USA;* [2]*Microelectronics-Photonics Program, Univ. of Arkansas, USA;* [3]*Arktonics, LLC, USA;* [4]*ASM, USA;* [5]*Dept. of Electrical Engineering, Wilkes Univ., USA;* [6]*Dept. of Metallurgical and Materials Engineering, Univ. of Alabama, USA;* [7]*Dept. of Chemistry and Physics, Univ. of Arkansas at Pine Bluff, USA;* [8]*Thayer School of Engineering, Dartmouth College, USA;* [9]*Dept. of Engineering, Univ. of Massachusetts Boston, USA.* SiGeSn/GeSn/SiGeSn single and multiple quantum well (MQW) structures were characterized. The SiGeSn barriers provide a strong carrier confinement with sufficient barrier height, leading to the lasing with MQW device up to 90 K.

STu3N.4 • 13:45

O-band InAs/GaAs Quantum Dot Micro-disk Lasers on SOI by in-situ hybrid epitaxy, Bin Zhang[1], Wei W. Qi[1], Ting Wang[1], Jianjun Zhang[1]; [1]*Inst. of Physics, China.* By implementing III-V/Si hybrid growth technique, we demonstrate the first InAs quantum-dot micro-disk laser on SOI substrates. Threshold pµmp power as low as 0.39 mW were achieved with the Q factor of 3900.

STu3N.5 • 14:00

Spatially Coherent Interlayer Exciton Lasing in an Atomically-Thin Heterostructure, Eunice Paik[1], Long Zhang[1], William Burg[2], Rahul Gogna[1], Emanuel Tutuc[2], Hui Deng[1]; [1]*Univ. of Michigan, USA;* [2]*Univ. of Texas, USA.* We demonstrate lasing in WSe_2-$MoSe_2$ heterostructure integrated in a silicon nitride grating cavity. Signatures of lasing include sharp increase in spatial coherence and super-linear increase in the emission intensity as photon number increases above unity.

13:00–15:00
STu3O • Emerging Visible Light Communication
Presider: Qiaoqiang Gan, State Univ. of New York at Buffalo, USA

STu3O.1 • 13:00 Tutorial

Visible-light Diode-lasers and Integrated Photonics for Lighting and High-bitrate Visible Light Communication, Boon S. Ooi[1]; [1]*King Abdullah Univ of Sci & Technology, Saudi Arabia.* The advent of AlInGaN-based devices operating in the violet to green visible-wavelength range has ushered in high performance solid-state lighting and gigahertz visible-light communication (VLC). In this tutorial, we will discuss the recent advances.

Boon S. Ooi (Fellow of OSA, SPIE, and IoP; Ph.D. degree from the University of Glasgow, UK, 1994) joined King Abdullah University of Science and Technology (KAUST) in 2009, from Lehigh University (USA). His group focuses on lasers for solid-state lighting, visible-light and underwater-wireless-optical communication, and nanostructures for energy harvesting.

STu3O.2 • 14:00

Integrated Silicon Photodetector in Thin Film Lithium Niobate Platform for Visible Wavelength Band, Boris Desiatov[1], Marko Loncar[1]; [1]*Harvard Univ., USA.* We demonstrate design, fabrication and characterization of amorphous silicon photodetector on lithium niobate photonic platform at visible wavelengths. The device shows the best responsivity of 10mA/W and dark current of less than 0.5nA.

CLEO: Applications & Technology

13:00–15:00
ATu3P • A&T Topical Review on Progress in the Semiconductor Laser Technology I

ATu3P.1 • 13:00
Double-side pumped membrane external-cavity surface-emitting laser (MECSEL) with increased efficiency emitting > 3 W in the 780 nm region, Hermann Kahle[1], Hoy-My Phung[1], Jussi-Pekka Penttinen[1], Patrik Rajala[1], Antti Tukiainen[1], Sanna Ranta[1], Mircea Guina[1]; [1]*Optoelectronics Research Centre (ORC) - Physics, Tampere Univ., Finland.* We demonstrate a double-side pumped MECSEL emitting more than 3 W of output power in the 780 nm wavelength region. The laser exhibits an efficiency as high as 34.4 %.

ATu3P.2 • 13:15
Direct Tunneling Modulation of Semiconductor Lasers, Junyi Qiu[1], Milton Feng[1], Nick Holonyak[1]; [1]*Univ. of Illinois at Urbana-Champaign, USA.* Direct tunneling modulation of semiconductor lasers is realized experimentally in the three-terminal transistor laser through the interaction between the photon absorption by voltage-controlled intra-cavity photon-assisted tunneling and the photon generation by quantum-well recombination.

ATu3P.3 • 13:30 Invited
Semiconductor Lasers for Next-generation Applications, Takeo Kageyama[1]; [1]*QD Laser, Inc., Japan.* In this presentation, we will review emerging semiconductor laser applications which have developed remarkably in recent years, such as precision laser machining, variety of sensing, Si-photonics and retinal projection eye wear.

ATu3P.4 • 14:00 Invited
Photonic Crystal Surface Emitting Lasers, Richard Hogg[1]; [1]*Glasgow Univ., UK.* Abstract not available.

13:00–15:00
ATu3Q • A&T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors I

ATu3Q.1 • 13:00
Extending EUV to the High-NA EUV Regime. Patrick Naulleau[1], [1]*Lawrence Berkeley National Labs, USA.* Abstract not available.

ATu3Q.2 • 13:30
Nanopatterning of Things: from Metals, Oxides to Quantum Dots. Yoen Sik Jung[1], [1]*KAIST, South Korea.* This talk will introduce deep-nanoscale fabrication technologies based on synergic combinations of self-assembly, photolithography, and transfer-printing applicable to a variety of material systems including polymers, oxides, metals, quantum nanostructures for high-performance sensors, photovoltaics, and displays.

ATu3Q.3 • 14:00
Quantifying Improvements in Field to Field and Wafer to Wafer CD Variation from Laser Bandwidth Variation. Will Conley[1], [1]*Cymer LLC, USA.* Abstract not available.

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C

Joint

CLEO: QELS-Fundamental Science

JTu3A • Symposium on Quantum Information in Time-Frequency Domain I—Continued

JTu3A.5 • 14:30
Spectral phase coherence in HOM interferometry, Navin B. Lingaraju[1], Hsuan-Hao Lu[1], Suparna Seshadri[1], Poolad Imany[1], Daniel E. Leaird[1], Joseph M. Lukens[2], Andrew M. Weiner[1]; [1]*Purdue Univ., USA;* [2]*Quantum Information Science Group, Oak Ridge National Lab, USA.* We examine the role of spectral phase in Hong-Ou-Mandel interference by comparing interferograms for pure and mixed states. We find that HOM interference cannot be taken as a signature of coherent frequency superpositions.

JTu3A.6 • 14:45
High-Dimensional Energy-Time Entanglement up to 6 Qubits per Photon through Biphoton Frequency Comb, Kai-chi Chang[1]; [1]*UCLA, USA.* We demonstrate high-dimensional entanglement with ≈ 6 qubits per photon via mode-locked biphoton frequency comb. Hong-Ou-Mandel quantum revival is observed with 61 time-bins and 99.8% visibility.

FTu3B • PT Symmetry & Exceptional Points—Continued

FTu3B.5 • 14:15
Optical amplification at exceptional points, Qi Zhong[1], Sahin K. Ozdemir[2], Alexander Eisfeld[3], A. Metelmann[4], Ramy El-Ganainy[1]; [1]*Michigan Technological Univ., USA;* [2]*Pennsylvania State Univ., USA;* [3]*Max Planck Inst. for the Physics of Complex Systems, Germany;* [4]*Freie Univ., Germany.* We propose a new optical amplifier geometry based on exceptional points. Compared to its standard counterpart device, the proposed structure relaxes the limitation imposed by the gain-bandwidth product.

FTu3B.6 • 14:30
Breakdown of Non-Hermitian Hamiltonian for Correlated Multi-photon Transport Due to Reservoir-induced Correlation Changes, Zihao Chen[1], Yao Zhou[1], Jung-Tsung Shen[1]; [1]*Washington Univ. in St. Louis, USA.* We present a theoretical analysis of multi-photon transport in the presence of reservoir, and unearth the breakdown of widely adopted non-Hermitian Hamiltonian descriptions in the dissipative regime due to reservoir-induced changes of correlations.

FTu3B.7 • 14:45
Non-Hermitian Engineered TCC VCSEL for LIDAR Remote Sensing Technologies, Mohammad H. Teimourpour*[2], Hamed Dalir[1], Elham Heidari[3], Volker J. Sorger[4], Ray T. Chen[3]; [1]*Omega Optics Inc., USA;* [2]*College of Optical Sciences, The Univ. of Arizona, USA;* [3]*ECE Dept., Univ. of Texas at Austin, USA;* [4]*The George Washington Univ., USA.* We present the main aspects of a new approach to achieve a single mode operation in TCC-VCSEL array based on (1) increasing the spacing of the eigenfrequencies of supermodes, (2) Q-enhancing of the fundamental supermodes.

FTu3C • Polaritonic Interactions in Transition Metal Dichalcogenide—Continued

FTu3C.3 • 14:15
The Ultimate Purcell Factor in Van der Waals Heterostructures, Yaniv Kurman[1], Peter Schmidt[2], Frank H. Koppens[2,3], Ido Kaminer[1]; [1]*Israel Inst. of technology, Israel;* [2]*ICFO-Institut de Ciencies Fotoniques, Spain;* [3]*ICREA – Institució Catalana de Recerça i Estudis Avancats, Spain.* We find what mechanisms limit fundamental light-matter interactions of plasmons confined to the atomic scale, when interfacing two-dimensional semiconductor emitters. We show how nonlocality governs the dynamics, limiting the Purcell factor yet reaching ultra-strong coupling.

FTu3C.4 • 14:30
Strong Light-Matter Interaction in Monocrystalline Gold Nanodisks Coupled to Tungsten Disulfide, Nicolas Stenger[2,3], Mathias Geisler[2,3], Martijn Wubs[2,3], Sanshui Xiao[2,3], N. Mortensen[1,4]; [1]*Center for Nano Optics, Univ. of Southern Denmark, Denmark;* [2]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark;* [3]*Center for Nanostructured Graphene, Technical Univ. of Denmark, Denmark;* [4]*Danish Inst. for Advanced Study, Univ. of Southern Denmark, Denmark.* Spectroscopy on plasmonic nanodisks coupled to single and multilayer tungsten disulfide show a Rabi splitting of 108 meV and 180 meV, respectively, the highest splitting reported in transition metal dichalcogenides coupled to plasmonic nanostructures.

FTu3C.5 • 14:45
Controllable coherent plasmon-exciton interaction in MoS_2 monolayer with gold nanorods through photothermal reshaping, Hu Aiqin[1]; [1]*Peking Univ., China.* The plasmon-exciton interactions in an individual gold nanorod with MoS_2 monolayer were investigated with single particle spectroscopy method. Based on photothermal reshaping, we in-situ tuned the surface plasmon resonance of single gold nanorod and investigate at room temperature.

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, *Networking Zone Booth 2605*

15:00–17:00 Coffee Break and Exhibit Only Time, *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, *Exhibit Hall Theater I*

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTu3D • Tailored Light-Matter Interactions—Continued

FTu3D.5 • 14:15
Optical skyrmions: a new topological state of light, Shai Tsesses[1], Evgeny Ostrovsky[1], Kobi Cohen[1], Bergin Gjonaj[2], Netanel H. Lindner[1], Guy Bartal[1]; [1]*Technion-Israeli Inst. of technology, Israel;* [2]*Albanian Univ., Albania.* We experimentally demonstrate a new topology for light: optical skyrmions. This discovery may allow a variety of applications, from stimulated creation of skyrmions in matter to new paradigms in optical information processing.

FTu3D.6 • 14:30
Implementing Optimal Field Configurations for Micromanipulation, Michael Horodynski[1], Matthias Kühmayer[1], Andre Brandstötter[1], Kevin Pichler[1], Ulrich Kuhl[2], Stefan Rotter[1]; [1]*Inst. for Theoretical Physics, Vienna Univ. of Technology (TU Wien), Austria;* [2]*Institut de Physique de Nice, Université Côte d'Azur, France.* We demonstrate both theoretically and experimentally how to achieve wave states that are optimal for transferring momentum, torque, etc. on a target of arbitrary shape embedded in an arbitrary environment.

FTu3D.7 • 14:45
Quantum State Filtering of Dual-rail Photons with Fiberized Plasmonic Metamaterial, Salih Yanikgonul[1,2], Anton N. Vetlugin[1], Ruixiang Guo[1], Angelos Xomalis[3], Giorgio Adamo[1], Cesare Soci[1], Nikolay I. Zheludev[1,3]; [1]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore;* [2]*Advanced Concepts and Nanotechnology, Inst. of Materials Research and Engineering, Singapore;* [3]*Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK.* We demonstrate quantum state filtering of dual-rail photons through single-photon interference on a fiberized plasmonic metamaterial, exploiting different optical response of the metamaterial to symmetric and anti-symmetric superpositions of double-path wavefunction of single-photons.

Executive Ballroom 210E

CLEO: Science & Innovations

STu3E • High Peak-Power Lasers & Technologies I—Continued

STu3E.4 • 14:30
First commissioning results of the Apollon laser on the 1 PW beam line, Dimitrios N. Papadopoulos[1]; [1]*LULI, France.* The Apollon 10 PW laser has recently demonstrated its capacity of generating >1 PW pulses with <22 fs duration. The complete commissioning results of the 1 PW beam line will be presented in this work.

STu3E.5 • 14:45
The 9.2 µm, 2 ps, Multi-Terawatt Laser at the Accelerator Test Facility (ATF) of Brookhaven National Lab, Mikhail N. Polyanskiy[1], Igor V. Pogorelsky[1], Marcus Babzien[1], Mark A. Palmer[1]; [1]*Brookhaven National Lab, USA.* A terawatt-class long-wave infrared (LWIR) laser based on chirped-pulse amplification of picosecond pulses in mixed-isotope, high pressure CO_2 amplifiers is in operation at ATF. An overview of the laser system as well as a summary of recent progress and status are presented.

Executive Ballroom 210F

STu3F • Terahertz Sensing & Devices—Continued

STu3F.5 • 14:15
Non-Scanning THz Spectral Characterization with a Microbolometer Focal Plane Array, Dogeun Jang[1], Yung Jun Yoo[1], Ki-Yong Kim[1]; [1]*Univ. of Maryland at College Park, USA.* We demonstrate a single-shot scheme in characterizing terahertz spectrum by using a microbolometer focal plane array. This method measures THz field autocorrelations and can characterize THz radiation up to 30 THz with high temporal resolution.

STu3F.6 • 14:30
A Luneburg Lens for the THz Region, Yasith Amarasinghe[1], Daniel M. Mittleman[1], Rajind Mendis[1]; [1]*Brown Univ., USA.* We implement a two-dimensional Luneburg lens for the THz region using a waveguide-based artificial-dielectric technology. The lens can focus an approximately 2-cm diameter input beam at 0.162 THz to a spot size of 3.4 mm.

STu3F.7 • 14:45
Photonics-based multi-spectral THz imaging using a dual-mode laser and a telecentric f-θ lens, Kiwon Moon[1], Il-Min Lee[1], Eui Su Lee[1], Kyung Hyun Park[1]; [1]*Electronics and Telecom Research Inst, South Korea (the Republic of).* We propose a continuous-wave THz imaging system using a semiconductor dual-mode laser, a photomixer and a Schottky barrier diode. Through the broadband frequency tunability of the dual-mode laser, high-resolution multi-spectral THz images were obtained.

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, *Networking Zone Booth 2605*

15:00–17:00 Coffee Break and Exhibit Only Time, *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, *Exhibit Hall Theater I*

Executive Ballroom 210G

Joint

JTu3G • Symposium on Space-borne Quantum Sensors—Continued

JTu3G.4 • 14:30 Invited
Quantum Science Experiments with Micius Satellite, Cheng-Zhi Peng[1,2]; [1]*Univ of Science and Technology of China, China;* [2]*Synergetic Innovation Center of Quantum Information and Quantum Physics, China.* The quantum science satellite have been launched successfully in China. Utilizing this satellite, we have completed a series of quantum experiments in space. Here, I will introduce these experiments and our future plans.

Executive Ballroom 210H

CLEO: Science & Innovations

STu3H • Biophotonics & Optofluidics—Continued

Professor Yang works on microscopy and wavefront shaping. His group invented the ePetri technology and Fourier Ptychography for microscopy. His group invented digital optical phase conjugation technology and was the first to apply wavefront shaping into biophotonics. He is a fellow of the Coulter foundation, AIMBE, OSA and SPIE.

Meeting Room 211 A/B

CLEO: Applications & Technology

ATu3I • Ultrafast Laser Processing—Continued

ATu3I.5 • 14:15
Femtosecond + Nanosecond Multiple Pulse Train from a Thin Disk Regenerative Amplifier, Atabak Marandi[1], Florian Fink[1], Joerg Neuhaus[1], Mikhail Larionov[1]; [1]*Dausinger + Giesen GmbH, Germany.* Demonstration of a regenerative amplifier with "mixed pulse trains" for micromachining: femtosecond pulses for effective ablation directly followed by nanosecond pulses for smoothening of the surface amplified within one single thin disk resonator.

ATu3I.6 • 14:30
Thermal damage free materials processing by using ultrashort pulse laser, Sungkwon Shin[1], Jungyu Hur[1], Jongkab Park[1], Dohun Kim[1]; [1]*AP Systems Corporation, South Korea (the Republic of).* We report thermal damage free processing in Invar, polyimide, and soda-lime glass by using an ultrashort pulse laser. Experimental results and a toy model for thermal accumulation will be discussed.

ATu3I.7 • 14:45
Efficient ablation of silicon with a high power GHz femtosecond laser source, Eric Mottay[1], Guillaume Bonamis[1,2], Konstantin M. Mishchik[1], John Lopez[2], Eric Audouard[1], Clemens Hoenninger[1], Inka Manek-Honninger[2]; [1]*Amplitude, France;* [2]*Univ. of Bordeaux, France.* Ablation of silicon using high power GHz femtosecond lasers achieves specific removal rate of 2.5 mm^3/min/W. Ablation morphologies are discussed in terms of thermal and non-thermal mechanisms.

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, *Networking Zone Booth 2605*

15:00–17:00 Coffee Break and Exhibit Only Time, *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, *Exhibit Hall Theater I*

Meeting Room
211 C/D

CLEO: Science & Innovations

STu3J • Kerr Frequency Microcombs—Continued

STu3J.3 • 14:15
Broadband Efficient Soliton Microcombs in Pulse-Driven Photonic Microresonators, Miles H. Anderson[1], Romain Bouchand[1], Ewelina Obrzud[2,3], Junqiu Liu[1], Sylvain Karlen[2], Steve Lecomte[2], Tobias Herr[2], Tobias J. Kippenberg[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*Swiss Center for Electronics and Microtechnology (CSEM), Switzerland;* [3]*Geneva Observatory/PlanetS, Dept. of Astronomy, Univ. of Geneva, Switzerland.* Broadband single-soliton based frequency combs, with a detectable repetition rate of 28 GHz, are efficiently generated through pulse-driving of a chip-based Si$_3$N$_4$ microresonator. We observe an influence of the pulse-driving rate on the comb mode linewidth.

STu3J.4 • 14:30
Electrically Driven Ultra-compact Photonic Integrated Soliton Microcomb, Arslan Raja[1], Andrey S. Voloshin[2], Hairun Guo[1], Sofya E. Agafonova[2], Junqiu Liu[1], Alexander S. Gorodnitskiy[2], Maxim Karpov[1], Nikolay G. Pavlov[2], Erwan Lucas[1], Ramzil R. Galiev[2], Artem E. Shitikov[2], John D. Jost[1], Michael L. Gorodetsky[2], Tobias J. Kippenberg[1]; [1]*École Polytechnique Fédérale de Lausanne, Switzerland;* [2]*Russian Quantum Center, Russia.* We demonstrate a current-initiated soliton microcomb by injection-locking a multi-frequency laser diode to a chip-scale high-Q Si3N4 microresonator. This approach offers a pathway for integrated and ultra-compact microcomb source for high-volume applications.

STu3J.5 • 14:45
Long-Term Stabilization and Operation of a Soliton Micro-Comb for 9-Days, Tong Lin[1], Avik Dutt[1], Xingchen Ji[1], Christopher T. Phare[1], Chaitanya Joshi[1], Oscar A. Jimenez[1], Min C. Shin[1], Alexander Gaeta[1], Michal Lipson[1]; [1]*Columbia Univ., USA.* We report the long-term stabilization of a soliton micro-comb over 9 days of continuous operation. Using an integrated heater, the original pump-cavity detuning is maintained with a simple active feedback method.

Meeting Room
212 A/B

CLEO: Applications & Technology

ATu3K • Biophotonic Spectroscopy—Continued

ATu3K.5 • 14:15
High-Sensitivity Coherent Raman Spectroscopy with Doppler Raman, David Smith[1], Jeff Field[1], David Winters[1], Scott Domingue[2], Jesse Wilson[1], Daniel Kane[3], Randy Bartels[1]; [1]*Colorado State Univ., USA;* [2]*KM Labs, USA;* [3]*Mesa Photonics, USA.* Doppler Raman spectroscopy is a novel detection scheme for impulsively stimulated Raman scattering that unlocks high-sensitivity detection of low frequency Raman vibrational modes from 10cm^{-1} to 1500cm^{-1} through signal amplification in the external detection system.

ATu3K.6 • 14:30
Shining the Light to Terahertz Spectroscopy of nL-Volume Biological Samples, Sergey Mitryukovskiy[1], Mélanie Lavancier[1], Romain Peretti[1], Jean-François Lampin[1], Théo Hannotte[1], Flavie Braud[1], Emmanuel Dubois[1], Goedele Roos[2]; [1]*Inst. of Electronics, Microelectronics and Nanotechnology (IEMN), CNRS/Univ. Lille, France;* [2]*Unit of Structural and Functional Glycobiology (UGSF), CNRS/Univ. Lille, France.* We present a technique allowing the confinement of a broadband terahertz pulse to a few-nL volume. The method is approved in terahertz time-domain spectroscopy study of biological samples and further perspectives are discussed.

ATu3K.7 • 14:45
SERS Detection of Trace Level Tetrahydrocannabinol in Body Fluid , Kundan Sivashanmugan[1], Kenneth Squire[1], Yong Zhao[1,2], Ailing Tan[1,2], Joseph Kraai[1], Gregory Rorrer[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*Yanshan Univ., China.* Silver nanoparticles were grown on a diatom photonic crystal surface to create a hybrid plasmonic-biosilica nanostructure for surface-enhanced Raman scattering. Ultra-sensitive and quantitative detection of Tetrahydrocannabinol in body fluid was achieved to counter measure drug abuse.

Meeting Room
212 C/D

CLEO: Science & Innovations

STu3L • Mode-Locked Fiber Lasers I—Continued

STu3L.5 • 14:15
All-fiber dual-wavelength mode-locked laser by using low-birefringence Lyot-filter and carbon nanotube, Yuanjun Zhu[1], Fulin Xiang[1], Pengtao Yuan[1], Neisei Hayashi[1], Chao Zhang[1], Lei Jin[1], Sze Y. Set[1], Shinji Yamashita[1]; [1]*Research Center for Advanced Science and Technology, The Univ. of Tokyo, Japan.* We firstly demonstrate a dual-wavelength mode-locked EDF laser by utilizing a low-birefringence Lyot-filter and CNT, which delivers dual-wavelength output centers at 1532 nm and 1556 nm corresponds to the difference frequency of 3.02 THz.

STu3L.6 • 14:30
Jitter-Free Multi-Wavelength Fiber Sources using Intermodal Solitons, Lars Rishoj[1], Boyin Tai[1], Fengyuan Deng[1], Ji-Xin Cheng[1], Siddharth Ramachandran[1]; [1]*Boston Univ., USA.* We demonstrate energetic (30nJ) dual-wavelength ultrashort-pulse sources via soliton self-mode conversion in a multimode fiber that are naturally temporally synchronized. Power fluctuations of resultant sum-frequency signals are 11.4dB lower than conventional fiber based dual-wavelength approaches.

STu3L.7 • 14:45
Real-time Observation of Soliton Build-up Dynamics in Bidirectional Mode-Locked Fibre Lasers, Maria Chernysheva[1,2], Igor Kudelin[1], Srikanth Sugavanam[1]; [1]*Aston Univ., UK;* [2]*Leibniz Inst. of Photonic Technology, Germany.* By using newly emerged high precision real-time measurement technologies of spatio-temporal intensity reconstruction and dispersive Fourier transformation (DFT), we have experimentally observed the buildup dynamics of solitons in a bidirectional ultrafast fibre laser.

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, *Networking Zone Booth 2605*

15:00–17:00 Coffee Break and Exhibit Only Time, *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, *Exhibit Hall Theater I*

Marriott Salon I & II | Marriott Salon III | Marriott Salon IV

Joint

JTu3M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials I—Continued

JTu3M.4 • 14:15
Unveiling the Mechanism of Highly-efficient Nonlinear Responses from Film-coupled Plasmonic Structures, Qixin Shen[1], Thang B. Hoang[1], Guoce Yang[1], Virginia D. Wheeler[2], Maiken H. Mikkelsen[1]; [1]*Duke Univ., USA;* [2]*USA Naval Research Lab, USA.* We investigate the mechanism of highly efficient nonlinear responses from dielectric materials in a tiny gap of less than 7 nm between a gold film and metallic nanostructures, which offers potential for on-chip nonlinear devices.

JTu3M.5 • 14:30 Invited
Title to be Determined, David A. Reis[1]; [1]*Stanford Univ., USA.* Abstract not available.

CLEO: Science & Innovations

STu3N • Lasers on Silicon & Nanolasers—Continued

STu3N.6 • 14:15
High-temperature Continuous-wave Operation of 1.3-µm Membrane Distributed Reflector Lasers on SiC, Suguru Yamaoka[1], Ryo Nakao[1], Takuro Fujii[1], Koji Takeda[1], Tatsurou Hiraki[1], Hidetaka Nishi[1], Takaaki Kakitsuka[1], Tai Tsuchizawa[1], Shinji Matsuo[1]; [1]*NTT Device Technology Labs, Japan.* We demonstrate continuous-wave operation of 1.3-µm membrane distributed reflector lasers on SiC at a 130°C stage temperature. The laser, with its large thermal conductivity and optical confinement, is promising for high-temperature operation.

STu3N.7 • 14:30
Sub-wavelength single-mode all-inorganic perovskite $CsPbBr_3$ nanolaser, Zhengzheng Liu[1], Jie Yang[2], Juan Du[1], Xiaosheng Tang[2], Yuxin Leng[1], Ruxin Li[1]; [1]*Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Chongqing Univ., China.* We report the single-mode, high-quality, low-threshold picosecond pulses laser whose physical volume is only ~0.49 λ^3 (where λ is the lasing wavelength in air) from an individual all-inorganic perovskite $CsPbBr_3$ nanocuboid.

STu3N.8 • 14:45
Measuring the Frequency Response of Metallic Nanolasers, Chi Xu[1], William Hayenga[1], Mercedeh Khajavikhan[1], Patrick LiKamWa[1]; [1]*Univ. of Central Florida, CREOL, USA.* The frequency response of metallic nanolasers are evaluated theoretically and experimentally. The predicted modulation bandwidth is ~ 289 GHz, and the experiments show an effective modulation current efficiency factor (MCEF) of ~143.8 $GHz/mA^{1/2}$.

STu3O • Emerging Visible Light Communication—Continued

STu3O.3 • 14:15
Liquid-Crystal-Based Visible-Light Integrated Optical Phased Arrays, Jelena Notaros[1], Milica Notaros[1], Manan Raval[1], Michael R. Watts[1]; [1]*MIT, USA.* Liquid-crystal-based integrated optical phased arrays are proposed and experimentally demonstrated for the first time as a method for low-power and compact visible-light beam steering. Beam steering of 10.5° within ±3.5V at a 632.8nm wavelength is shown.

STu3O.4 • 14:30
Integrated-Phased-Array-Based Visible-Light Near-Eye Holographic Projector, Jelena Notaros[1], Manan Raval[1], Milica Notaros[1], Michael R. Watts[1]; [1]*MIT, USA.* An integrated-phased-array-based visible-light holographic projector is proposed as a scalable solution towards the next generation of augmented-reality head-mounted displays. A passive pixel-based architecture is developed and projection of a wire-frame cube is experimentally demonstrated.

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, *Networking Zone Booth 2605*

15:00–17:00 Coffee Break and Exhibit Only Time, *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, *Exhibit Hall Theater I*

CLEO: Applications & Technology

ATu3P • A&T Topical Review on Progress in the Semiconductor Laser Technology I—Continued

ATu3P.5 • 14:30
100 GHz colliding pulse mode locked quantum dot lasers directly grown on Si for WDM application, Songtao Liu[1], Xinru Wu[1,2], Justin Norman[1], Daehwan Jung[1], MJ Kennedy[1], Hon Ki Tsang[2], Arthur Gossard[1], John Bowers[1]; [1]*Univ. of California, Santa Barbara, USA;* [2]*The Chinese Univ. of Hong Kong, China.* We demonstrate the first 100 GHz 5[th] harmonic colliding pulse mode locked quantum dot laser directly grown on CMOS compatible on axis (001) silicon substrate with ~ 0.9 Tb/s PAM-4 transmission capacity.

ATu3P.6 • 14:45
High repetition-rate pulse generation from SESAM-free electrically pumped VECSEL, Nikolai B. Chichkov[1], Amit Yadav[1], Tasnim Munshi[2], Ksenia Fedorova[2], Evgeny Viktorov[3], Edik U. Rafailov[1]; [1]*Aston Inst. of Photonic Technologiess, Aston Univ., UK;* [2]*Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg, Germany;* [3]*ITMO Univ., Russia.* High repetition-rate pulse generation in a SESAM-free electrically pumped VECSEL is demonstrated. The laser produces output pulses with a duration of 140 ps, pulse energy of 3.6 pJ, and repetition rate of 1.97 GHz.

ATu3Q • A&T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors I—Continued

15:00–16:30 Meet the OSA Publishing Journal Editors Ice Cream Social, *Networking Zone Booth 2605*

15:00–17:00 Coffee Break and Exhibit Only Time, *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 OIDA: Market Trends: Opportunities in Optics and Photonics, *Exhibit Hall Theater I*

Joint

17:00–19:00
JTu4A • Symposium on Quantum Information in Time-Frequency Domain II
Presider: To Be Announced

JTu4A.1 • 17:00 Invited
Generation of Scalable Cluster States in the Quantum Optical Frequency Comb, Olivier Pfister[1]; [1]*Univ. of Virginia, USA.* Record-level quantum information scalability can be achieved by entangling the multitude of quantum optical resonant fields (qumodes), emitted by a single optical parametric oscillator, into large-scale cluster states suitable for quantum computing and quantum simulation.

JTu4A.2 • 17:30 Invited
Tailored Non-Gaussian Multimode States of Quantum Light, Nicolas Treps[1]; [1]*Laboratoire Kastler Brossel, Sorbonne Université, France.* We demonstrate experimentally non-Gaussian states of light from mode-dependant photon subtraction on multimode entangled Gaussian States. We study the propagation properties of non-gaussianity within the graph, and its implications on the nature of entanglement.

JTu4A.3 • 18:00 Invited
Quantum Information Processing with Frequency-bin Qubits: Progress, Status, and Challenges, Joseph M. Lukens[1]; [1]*Oak Ridge National Lab, USA.* Frequency-bin encoding has emerged as a promising approach for fiber- and chip-compatible quantum information processing. We overview the basic theory and experiments, as well as offer perspectives on opportunities for continued advances.

CLEO: QELS-Fundamental Science

17:00–19:00
FTu4B • Manipulation of Symmetries in Optics
Presider: To Be Announced

FTu4B.1 • 17:00
3D Parity Time symmetry in 2D photonic lattices utilizing artificial gauge fields in synthetic dimensions, Eran Lustig[1], Yonatan Plotnik[1], Zhaoju Yang[1], Moti Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* We study Parity-Time symmetric lattice models in three dimensions by utilizing a synthetic modal dimension of a 2D lattice of coupled waveguides.

FTu4B.2 • 17:15
A Random Anti-Laser Implemented by Coherent Perfect Absorption in a Disordered Medium, Kevin Pichler[1], Matthias Kühmayer[1], Julian Böhm[2], Andre Brandstötter[1], Philipp Ambichl[1], Ulrich Kuhl[2], Stefan Rotter[1]; [1]*Inst. for Theoretical Physics, Vienna Univ. of Technology, Austria;* [2]*Institut de Physique de Nice, Université Côte d'Azur, France.* We report the first experimental implementation of coherent perfect absorption in a disordered medium. We thereby realize a "random anti-laser", which produces the time-reversed process of random lasing at threshold.

FTu4B.3 • 17:30
Experimental Demonstration of 2D PT-Symmetric Graphene: Bulk Properties and Edge States, Mark Kremer[1], Tobias Biesenthal[1], Lukas Maczewsky[1], Matthias Heinrich[1], Ronny Thomale[2], Alexander Szameit[1]; [1]*Inst. of Physics, Univ. of Rostock, Germany;* [2]*Dept. of Physics and Astronomy, Univ. of Würzburg, Germany.* We report the first realization of a two-dimensional PT-symmetric crystalline structure, based on a novel isotropic loss mechanism. By probing bulk and edge properties, we shed new light on the interplay between PT-symmetry and topology.

FTu4B.4 • 17:45
Bound states in the continuum through environment engineering, Alexander Cerjan[1], Chia Wei Hsu[2], Mikael C. Rechtsman[1]; [1]*Pennsylvania State Univ., USA;* [2]*Electrical Engineering, Univ. of Southern California, USA.* We propose a new paradigm for realizing bound states in the continuum (BICs): engineering radiating channels in the environment. Examples include points and lines of BICs in a structure embedded in a periodic medium.

FTu4B.5 • 18:00 Invited
Irreversible Refractive-Index and Water-Walled Photonics, Tal Carmon[1]; [1]*Technion Israel Inst. of Technology, Israel.* Coupling light from a tapered fiber into a resonator was recently transformed to permit coupling to rapidly-spinning resonators as well as to resonators made strictly of water. I will present recent experiments where light is transmitted in only one direction of the fiber, record finesse is observed, and water-waves exchange energy with light.

17:00–19:00
FTu4C • Nanophotonic Platforms for Optical Computing & Deep Learning
Presider: Jonathan Fan, Stanford Univ., USA

FTu4C.1 • 17:00 Invited
Optical Computing of Spatial Differentiation Without Fourier Optics, Zhichao Ruan[1]; [1]*Zhejiang Univ., China.* We propose optical analog computing of spatial differentiation with two new effects: the surface plasmon excitation and the spin Hall effect of light. Also we experimentally demonstrate their applications on edge-enhanced imaging.

FTu4C.2 • 17:30
Photonic Recurrent Ising Sampler, Charles Roques-Carmes[1], Yichen Shen[1], Cristian Zanoci[1], Mihika Prabhu[1], Fadi Atieh[1], Li Jing[1], Tena Dubcek[1], Vladimir Ceperic[1], John D. Joannopoulos[1], Dirk R. Englund[1], Marin Soljacic[1]; [1]*MIT, USA.* We present the Photonic Recurrent Ising Sampler (PRIS), an algorithm tailored for photonic parallel networks, that can sample distributions of arbitrary Ising problems. The PRIS finds the ground state of general Ising problems and probes critical exponents of universality classes.

FTu4C.3 • 18:00
Deep Learning for Design and Retrieval of Plasmonic Nanostructures, Michael Mrejen[2], Itzik Malkiel[1], Achiya Nagler[2], Uri Arieli[2], Lior Wolf[1], Haim Suchowski[2]; [1]*Computer Science, Tel Aviv Univ., Israel;* [2]*School of Physics and Astronomy, Tel Aviv Univ., Israel.* We experimentally demonstrate a novel Deep Learning method capable of retrieving subwavelength dimensions from solely far-field measurements. Moreover, it also directly addresses the inverse problem i.e. obtaining a geometry for a desired electromagnetic response.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

17:00–19:00
FTu4D • Thermal Photonics
Presider: To Be Announced

FTu4D.1 • 17:00
Dual-Band Quasi-Coherent Radiative Thermal Source, Ryan Starko-Bowes[2], Xueji Wang[1], Jin Dai[1], Ward D. Newman[1], Sean Molesky[2], Limei Qi[3], Aman Satija[1], Ying Tsui[2], Manisha Gupta[2], Robert Fedosejevs[2], Sandipan Pramanik[2], Yi Xuan[1], Zubin Jacob[1]; [1]*Birck Nanotechnology Center, Purdue Univ., USA;* [2]*Univ. of Alberta, Canada;* [3]*School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China.* We design, fabricate and characterize the spectral, polarization, angular and temperature dependence of a microstructured SiC thermal infrared source; achieving independent control of the frequency and polarization of thermal radiation in two spectral bands.

FTu4D.2 • 17:15
High-Temperature Refractory Metasurfaces For Solar Thermophotovoltaic Energy Harvesting, Chun-Chieh Chang[1,2], Wilton J. Kort-Kamp[3,4], John Nogan[5], Ting S. Luk[5], Abul Azad[1], Antoinette Taylor[6], Diego A. Dalvit[4], Milan Sykora[7], Hou-Tong Chen[1]; [1]*Center for Integrated Nanotechnologies, Los Alamos National Lab, USA;* [2]*Inst. of Electro-Optical Science and Technology, National Taiwan Normal Univ., Taiwan;* [3]*Center for Nonlinear Studies, Los Alamos National Lab, USA;* [4]*Theoretical Division, Los Alamos National Lab, USA;* [5]*Center for Integrated Nanotechnologies, Sandia National Labs, USA;* [6]*Chemistry, Life, and Earth Sciences Directorate, Los Alamos National Lab, USA;* [7]*Chemistry Division, Los Alamos National Lab, USA.* We experimentally demonstrate refractory metasurfaces for solar thermophotovoltaics (STPV) with tailored absorptance and emittance thermally stable up to at least 1200 C.

FTu4D.3 • 17:30 Invited
High Temperature Optical Metamaterials, Alexander Petrov[1,3], Manohar Chirumamilla[1], Gnanavel Vaidhyanathan[2], Tobias Krekeler[1], Matthias Graf[2], Dirk Jalas[1], Martin Ritter[1], Michael Störmer[2], Manfred Eich[1,2]; [1]*Hamburg Univ. of Technology, Germany;* [2]*Helmholz-Zentrum Geesthacht, Germany;* [3]*ITMO Univ., Russia.* We investigate spectrally selective high temperature stable metamaterial emitters for thermophotovoltaics. We demonstrate band-edge emitters based on a W-HfO_2 multilayer metamaterial stable up to 1400°C. Conditions for improved selectivity and thermal stability are discussed.

FTu4D.4 • 18:00
Non-Hermitian Selective Thermal Emitters Using Hybrid Plasmonic-Photonic Resonators, Chloe F. Doiron[1,2], Gururaj V. Naik[1]; [1]*Electrical and Computer Engineering, Rice Univ., USA;* [2]*Applied Physics Graduate Program, Smalley-Curl Inst., Rice Univ., USA.* We experimentally demonstrate non-Hermitian physics of thermal emitters by coupling a plasmonic resonator with high losses to a bound-state-in-continuum dielectric resonator with low losses. Our thermal emitter exhibits passive PT-symmetry while operating at 700°C.

Executive Ballroom 210E

CLEO: Science & Innovations

17:00–19:00
STu4E • High Peak-Power Laser & Technologies II
Presider: Dimitris Papadopoulos LULI, France

STu4E.1 • 17:00
Latest developments at Amplitude in the frame of the ELI-HU projects. PW laser at high repetition rate, Franck Falcoz[1]; [1]*Amplitude, France.* We will present in this paper the latest development made in the frame of the ELI projects. We will focus in particular on the development of a 50J @ 532nm, 10Hz pump laser that is compatible with TiSa or OPCPA pumping. The technology used and the performances obtained will be presented.

STu4E.2 • 17:15
Design study of two-cycle bandwidth, single-color pumped OPCPA chain, Szabolcs Tóth[1], Tomas Stanislauskas[2], Ignas Balciunas[2], Rimantas Budriunas[2], Gediminas Veitas[2], Janos Csontos[1], Ádám Börzsönyi[1], Károly Osvay[1]; [1]*ELI-ALPS, ELI-HU Nonprofit Ltd., Hungary;* [2]*Light Conversion Ltd., Lithuania.* ELI-ALPS 1kHz SYLOS laser aims to deliver 5.5TW, two-cycle pulses for attosecond pulse and electron beam generation. In this study, broadband NOPCPA schemes were examined based on spectral multiplexing in different BBO and LBO configurations.

STu4E.3 • 17:30 Invited
Advanced Laser Technology for Attosecond and Femtosecond Spectroscopy, Hanieh Fattahi[1]; [1]*Max-Planck-Institut fur Quantenoptik, Germany.* Molecular fieldoscopy enables the direct measurement of the complex electric field of the emitted free-induction decay of excited molecules with an unparalleled sensitivity and specificity. In this talk, the novel methodology, lasers source, and preliminary results are presented.

STu4E.4 • 18:00
Long-Term Stabilization of Temporal and Spectral Drifts of a Burst-Mode OPCPA System, Nora Schirmel[1], Skirmantas Alisauskas[1], Thomas Hülsenbusch[1], Bastian Manschwetus[1], Christian Mohr[1], Lutz Winkelmann[1], Uwe Große-Wortmann[1], Jiaan Zheng[1], Tino Lang[1], Ingmar Hartl[1]; [1]*Deutsches Elektronen-Synchrotron, Germany.* We demonstrate a stabilization system for temporal and spectral drifts of an OPCPA pump-probe laser at the FLASH soft-X-ray FEL-facility. We achieve drifts of 5.7fs rms and 3.2nm rms, respectively over two days.

Executive Ballroom 210F

17:00–19:00
STu4F • Terahertz Spectroscopy
Presider: Aydin Babakhani, UCLA, USA

STu4F.1 • 17:00
Ultrafast Time-Domain Spectrometer in the 25 T Split Florida-Helix Magnet, Ashlyn D. Burch[1], Jeremy A. Curtis[1], Biplob Barman[1], A. G. Linn[1], Luke M. McLintock[1], Aidan L. O'Beirne[1], Matthew J. Stiles[1], John Reno[2], Stephen A. McGill[3], Denis Karaiskaj[4], David J. Hilton[1]; [1]*Univ. of Alabama at Birmingham, USA;* [2]*Center for Integrated Nanotechnologies, Sandia National Labs, USA;* [3]*National High Magnetic Field Lab, USA;* [4]*Physics, Univ. of South Florida, USA.* We custom-designed an optical pump-terahertz probe spectrometer to operate under the high external magnetic fields of the 25 T Split Florida-Helix and demonstrated the instrument use by studying a gallium arsenide multiple quantum well sample.

STu4F.2 • 17:15
Pressure- and Temperature-Dependent Terahertz Time-Domain Spectroscopy of Hydroquinone and its Clathrates, Wei Zhang[1], Xuanfu Zhu[2], Michael T. Ruggiero[2], Daniel M. Mittleman[1]; [1]*Brown Univ., USA;* [2]*Dept. of Chemistry, Univ. of Vermont, USA.* We study the low-energy dynamics of hydroquinone and its clathrates under pressure using terahertz time-domain spectroscopy. Transitions between different phases are observed. The absorption peaks are assigned to lattice vibrational modes using quantum-mechanical simulations.

STu4F.3 • 17:30
Terahertz Spectroscopy of Metal Halide Perovskites, Michael B. Johnston[1]; [1]*Univ. of Oxford, UK.* Metal halide perovskite semiconductors show great promise as photovoltaic cells. Transient terahertz conductivity spectroscopy on single crystals and vapor co-deposited thin films of these materials reveals the ultrafast charge dynamics in these direct bandgap semiconductors.

STu4F.4 • 17:45
Carrier Mobility and Conduction Anisotropy of Silicon by Sub-Bandgap Time-Resolved Terahertz Spectroscopy, Timothy J. Magnanelli[1], Edwin J. Heilweil[1], Jared K. Wahlstrand[1]; [1]*NIST, USA.* Low density charge mobility from below bandgap, two photon photoexcitation of silicon is interrogated using time resolved terahertz spectroscopy yielding high mobility values and directional conduction anisotropy contrasted with traditional Hall and single photoexcitation metrics.

STu4F.5 • 18:00 Invited
Hot Carrier Cooling in Tin- and Lead-based Metal Halide Perovskites. J. Lloyd-Hughes1, R. Milot[1]; [1]*University of Warwick, UK.* Terahertz photoconductivity spectroscopy and transient optical absorption gave insights into hot carrier cooling rates, charge mobilities and the electron-phonon interaction in Pb- and Sn-based metal halide perovskites.

Executive Ballroom
210G

Executive Ballroom
210H

Meeting Room
211 A/B

CLEO: Science & Innovations

17:00–19:00
STu4G • Miniaturizing Quantum Technology
Presider: Max Perez; ColdQuanta, USA

STu4G.1 • 17:00 Tutorial
Challenges in Miniaturising Cold Atom Quantum Technology, Matt Himsworth[1]; [1]*School of Physics & Astronomy, Univ of Southampton, UK.* I will discuss the current state of the art in integrating a miniaturising magneto optical traps (MOT) for quantum technology. The tutorial will cover on MOT geometries, vacuum systems, lasers, and optical elements.

Matt Himsworth leads the integrated atom-chip group at the University of Southampton. His PhD focused on novel cooling mechanisms using atom interferometry. After a postdoctoral position at the University of Oxford he was awarded a RAEng/EPSRC fellowship. He is a Co-I in the UK Quantum Hub for Sensors and Metrology.

STu4G.2 • 18:00 Invited
Integrated Photonic-Atomic Systems for Compact Precision Instrumentation, John Kitching[1]; [1]*Time and Frequency Division, NIST, USA.* Lasers are widely used in instrumentation based on atomic spectroscopy. We describe efforts to integrate atomic ensembles with chip-based single-mode photonics to enable a new generation of compact, manufacturable, high-performance devices.

17:00–19:00
STu4H • Innovations in Machine Learning & Microscopy
Presider: Jessica Houston; New Mexico State Univ., USA

STu4H.1 • 17:00
Machine Learning Assisted Raman in Optofluidics for User-Independent Biofluid Diagnostics, Emily E. Storey[1], Duxuan Wu[1], Amr S. Helmy[1]; [1]*Univ. of Toronto, Canada.* We present a self-contained microfluidic Raman device which achieves signal enhancement of several orders of magnitude and machine-learning-driven analysis which facilitates diagnostically significant biofluid composition analysis, with a physiologically relevant sensitivity below 50 µM.

STu4H.2 • 17:15
Cross-Modality Deep Learning Achieves Super-Resolution in Fluorescence Microscopy, Hongda Wang[1], Yair Rivenson[1], Yiyin Jin[1], Zhensong Wei[1], Ronald Gao[1], Harun Gunaydin[1], Laurent Bentolila[1], Comert Kural[2], Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA;* [2]*Ohio State Univ., USA.* Using cross-modality deep learning, we achieved super-resolution in fluorescence microscopy and established image transformations from a lower resolution microscopy modality to a higher resolution modality, without any parameter estimation or assumptions about the imaging system.

STu4H.3 • 17:30 Invited
Image-Guided Microfluidic Cell Sorter with Machine Learning, Yi Gu[1], Rui Tang[1], Alex Zhang[1], Yuanyuan Han[1], Yuhwa Lo[1]; [1]*Univ. of California San Diego, USA.* We demonstrated an image-guided cell sorter using the techniques of spatial-temporal coding for high throughput cell imaging, real-time image processing and machine learning for cell classification, and microfluidic device in a disposable cartridge for cell sorting.

STu4H.4 • 18:00
Photonic Crystal-Enhanced Fluorescence Imaging of Cardiovascular Biomarker with Machine Learning Analysis, Kenneth Squire[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* A photonic crystal-enhanced fluorescence imaging immunoassay biosensor is capable of detecting NT-proBNP as a cardiovascular biomarker at various concentrations. Utilizing machine-learning algorithms, we create a predictive model for the analyte quantification.

CLEO: Applications & Technology

17:00–19:00
ATu4I • Emerging Lasers for Device Fabrication
Presider: Manyalibo Matthews; Lawrence Livermore National Laboratory, USA

ATu4I.1 • 17:00 Invited
Femtosecond Laser Based Manufacturing of Tailored Flexible Electronics for OLED and OPV Applications, Jiyeon Choi[1], Youngzoo Yoo[2], Hyo Jung Kim[3], Hyun Hwi Lee[4], Eric Mottay[6], Rainer Kling[5]; [1]*South Korea Inst. of Machinery & Materials, South Korea;* [2]*DUKSAN HI-METAL CO., LTD, South Korea;* [3]*Pusan National Univ., South Korea;* [4]*POSTECH, South Korea (the Republic of);* [5]*ALPhANOV, France;* [6]*Amplitude, France.* This talk presents our approaches for laser based flexible electronics manufacturing. Femtosecond laser processing has been applied to increase the efficiency of organic semiconductors and to form electrodes on flexible substrates possessing novel transparent conductors.

ATu4I.2 • 17:30
Femtosecond Laser decapsulation of micro-electronics Including parameter study and redeposition control, Nicholas May[1], Sina Shahbazmohamadi[1]; [1]*REFINE Lab Univ. of CT, USA.* A recipe was constructed resulting in full laser decapsulation of a packaged micro-electronic device. A parametric study on a sub-130 fs laser scanning system considering redeposition control was carried out and quantified with light-confocal microscopy.

ATu4I.3 • 17:45
Single-crystalline Te-hyperdoped silicon via controlling the velocity of ultra-fast cooling during femtosecond-laser irradiation, Zixi Jia[1], Qiang Wu[1,2], Ride Wang[1], Xiaorong Jin[1], Song Huang[1], Jianghong Yao[1,2], Jingjun Xu[1,2]; [1]*Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ., China;* [2]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China.* We implement single-crystalline tellurium (Te)-hyperdoped silicon via controlling the velocity of ultra-fast cooling during femtosecond-laser irradiation, providing a new path of less defective semiconductor hyperdoping, has great potential in applications of low noise semiconductor devices.

ATu4I.4 • 18:00
Low-loss geometrical phase elements by ultrafast laser writing in silica glass, Yuhao Lei[1], Masaaki Sakakura[1], Lei Wang[1], Yanhao Yu[1], Rokas Drevinskas[1], Peter G. Kazansky[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* Femtosecond laser induced birefringence with negligible transmission loss in silica glass is observed. Ultra-low loss birefringent optical elements including UV retarders and geometric phase optics are demonstrated.

Meeting Room 211 C/D

CLEO: Science & Innovations

17:00–19:00
STu4J • Quantum Nanostructure
Presider: Daryl Beggs, Cardiff Univ., UK

STu4J.1 • 17:00
Enhanced Photo Response at Two-micron-wavelength Using GeSn/Ge Multiple-Quantum-Well Waveguide, Shengqiang Xu[1], Yi-Chiau Huang[2], Saeid Masudy-Panah[1], Xiao Gong[1], Yee-Chia Yeo[1]; *[1]National Univeristy of Singapore, Singapore; [2]Applied Materials Inc., USA.* GeSn multiple-quantum-well rib waveguide on Si substrate was fabricated with vertical p-i-n photodiode structure and was characterized at two-micron-wavelength. Enhanced external photo response was achieved as compared to surface-illuminated counterparts, thanks to the waveguide scheme.

STu4J.2 • 17:15
Formation of GeSn Multiple-Quantum-Well Microdisks on Insulating Platform toward Lasing Applications, Shengqiang Xu[1], Yi-Chiau Huang[2], Kwang Hong Lee[3], Kaizhen Han[1], Dian Lei[1], Wei Wang[1], Yuan Dong[1], Chuan Seng Tan[3,4], Xiao Gong[1], Yee-Chia Yeo[1]; *[1]National Univeristy of Singapore, Singapore; [2]Applied Materials Inc., USA; [3]Singapore MIT Alliance for Research and Technology (SMART), Singapore; [4]Nanyang Technological Univ., Singapore.* GeSn multiple-quantum-well microdisks are demonstrated on an 8-inch insulating platform, which was formed using direct wafer bonding technique. Whispering-gallery modes are identified through FDTD simulation, showing potential of such ultra-compact cavities for Group-IV lasing.

STu4J.3 • 17:30
Low threshold 1.55 µm Quantum dash microring lasers, Yating Wan[1], Daehwan Jung[1], Chen Shang[1], Noelle Collins[1], Ian MacFarlane[1], Justin Norman[1], Mario Dumont[1], Art Gossard[1], John Bowers[1]; *[1]Univ. of California Santa Barbara, USA.* We report the first room-temperature-continuous-wave (CW) operation of electrically-injected InAs quantum-dash microring lasers emitting at 1.55 µm telecom window. The microrings sustain CW lasing up to 55°C, while the lowest threshold current density is 528A/cm^2.

STu4J.4 • 17:45
Deterministic positioning of colloidal quantum dots on silicon nitride nanobeam cavities, Yueyang Chen[1], Albert Ryou[1], Max Friedfeld[1], Taylor Fryett[1], James Whitehead[1], Brandi Cossairt[1], Arka Majumdar[1]; *[1]Univ. of Washington, USA.* We experimentally demonstrated deterministic positioning of solution processed colloidal quantum dots on a silicon nitride nanobeam resonator, with potential applications in nonlinear optics, multi-functional optical devices, and on-chip, solid-state quantum simulators.

STu4J.5 • 18:00 Invited
Integrated versatile quantum dot-based photonics on silicon, Di Liang[1], Geza Kurczveil[1], Bassem Tossoun[1], Chong Zhang[1], Antoine Descos[1], Zhihong Huang[1], Xiaoge Zeng[1], Yingtao Hu[1], Marco Fiorentino[1], Raymond Beausoleil[1]; *[1]Hewlett Packard Labs, Hewlett Packard Enterprise, USA.* We review our recent progress to develop multiple robust InAs quantum-dot-based lasers and photodetectors on a heterogeneous silicon substrate. It enables a versatile photonic integration platform to build high-performance photonic chips for communications and computing.

Meeting Room 212 A/B

CLEO: Applications & Technology

17:00–19:00
ATu4K • Biosensing Technology
Presider: Andrea Armani; University of Southern California, USA

ATu4K.1 • 17:00 Invited
Dynamic Measurement of Blood Flow Using Laser Speckle Contrast Imaging, Abhishek Rege[1]; *[1]Vasoptic Medical, Inc., USA.* Laser speckle contrast imaging is able to noninvasively obtain blood flow information with high spatio-temporal resolution from optically accessible tissues. Such information has the potential to be useful for diagnostic and other clinical decision making.

ATu4K.2 • 17:30
High-Throughput and Label-Free Detection of Motile Parasites in Bodily Fluids Using Lensless Time-Resolved Speckle Imaging, Yibo Zhang[1], Hatice Ceylan Koydemir[1], Michelle M. Shimogawa[1], Sener Yalcin[1], Alexander Guziak[1], Tairan Liu[1], Ilker Oguz[1], Yujia Huang[1], Bijie Bai[1], Yilin Luo[1], Yi Luo[1], Zhensong Wei[1], Hongda Wang[1], Vittorio Bianco[1], Bohan Zhang[1], Rohan Nadkarni[1], Kent Hill[1], Aydogan Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* We present a lensless time-resolved speckle imaging technique for label-free, sensitive and rapid detection of motile parasites in bodily fluids, by using the locomotion of parasites as a biomarker and contrast mechanism.

ATu4K.3 • 17:45
Particle-Aggregation Based Virus Sensor Using Deep Learning and Lensless Digital Holography, Yichen Wu[1], Aniruddha Ray[1], Qingshan Wei[1], Alborz Feizi[1], Xin Tong[1], Eva Chen[1], Yi Luo[1], Aydogan Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* Deep learning-based lensless holographic microscopy enables a high-throughput and rapid read-out for a particle-aggregation-based virus sensor, achieving a high sensitivity of ~5 viral copies per µL.

ATu4K.4 • 18:00
Time-resolved oxygen monitoring in human breath, Charles L. Patrick[1], Jonas Westberg[1], Gerard Wysocki[1]; *[1]Princeton Unviersity, USA.* A small form-factor oxygen sensor is designed for respiratory monitoring to meet specifications: form-factor, sensitivity and real-time (<0.1 %$_v$ of O_2 at 100Hz). Two designs are demonstrated based on wavelength modulation spectroscopy (WMS) and Faraday rotation spectroscopy (FRS).

Meeting Room 212 C/D

CLEO: Science & Innovations

17:00–19:00
STu4L • Mode-Locked Fiber Lasers II
Presider: Maria Chernysheva Leibniz Institute of Photonic Technology, Germany

STu4L.1 • 17:00
Passive synchronization of Er- and Yb-doped mode-locked fiber lasers based on nonlinear amplifying loop mirror, Jing Zeng[1], Jiwei Gan[1], Qiang Hao[1], Ming Yan[2], Kun Huang[1], Heping Zeng[1,2]; *[1]Univ of Shanghai Science & Technology, China; [2]East China Normal Univ., China.* The pulse timing between polarization-maintaining Er- and Yb-doped mode-locked fiber lasers was passively stabilized by an all-optical synchronization scheme based on nonlinear amplifying loop mirror, showing a cavity mismatch tolerance up to 16.2 mm.

STu4L.2 • 17:15
Reduced graphene oxide coated photonic crystal fiber for all-fiber laser mode locking, Rodrigo M. Gerosa[1], Christiano J. de Matos[1], Pilar G. Vianna[1], Sergio H. Domingues[1]; *[1]MackGraphe – Graphene and Nanomaterials Research Center, Mackenzie Presbyterian Univ., Brazil.* The walls of two holes in a photonic crystal fiber were selectively coated with graphene oxide (GO) using a simple procedure. Thermally reducing GO then yielded 356-fs pulses in an all-fiber passively mode-locked ring laser.

STu4L.3 • 17:30 Invited
Functional Pulsed Fiber Lasers for Multicolor Stimulated Raman Scattering Microscopy, Yasuyuki Ozeki[1]; *[1]Univ. of Tokyo, Japan.* I present our development of picosecond pulsed fiber laser sources for realizing high-performance yet practical molecular-vibrational microscopy based on stimulated Raman scattering. Specifically, I introduce a fast wavelength-tunable pulse source and an ultralow-intensity-noise oscillator.

STu4L.4 • 18:00
Characterization of the CEO Phase Noise of an Erbium Fiber Frequency Comb, Christoph Tresp[1], Thomas Puppe[1], Ali Seer[1], Pierre Thoumany[1], Felix Rohde[1], Rafal Wilk[1]; *[1]TOPTICA Photonics AG, Germany.* We measure the carrier-envelope phase noise of our Er:fiber frequency comb based on difference frequency generation. Integrating from 70 mHz to 20 MHz we achieve an excellent RMS phase jitter of only 61 mrad.

Marriott Salon I & II	Marriott Salon III	Marriott Salon IV

Joint

CLEO: Science & Innovations

17:00–19:00
JTu4M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials II

JTu4M.1 • 17:00 Invited
Extreme nonlinear optics in two dimensional materials, Koichiro Tanaka[1]; [1]*Kyoto Univ., Japan.* We show recent progress of extreme non-linear optics in two dimensional materials. High-harmonic generation is confirmed not only in semiconductors but also metals under irradiation of mid-infrared femtosecond laser pulses. We found main mechanism changes according to the carrier doping status of the material.

JTu4M.2 • 17:30
Valleytronics on the subcycle timescale, Christoph P. Schmid[1], Stefan Schlauderer[1], Fabian Langer[1], Martin Gmitra[1], Jaroslav Fabian[1], Philipp Nagler[1], Tobias Korn[1], Christian Schüller[1], Peter Hawkins[2], Johannes T. Steiner[2], Ulrich Huttner[2], Markus Borsch[3], Benjamin Girodias[3], Stephan W. Koch[2], Mackillo Kira[3], Rupert Huber[1]; [1]*Univ. of Regensburg, Germany;* [2]*Univ. of Marburg, Germany;* [3]*Univ. of Michigan, USA.* Intense multi-terahertz waveforms drive electron-hole recollisions in monolayer WSe_2 and enable subcycle switching of the valley pseudospin. This dynamics manifests in high-odd-order sideband generation and opens the door to valleytronic protocols at optical clock rates.

JTu4M.3 • 17:45
Ultrafast laser pulse induced topological resonance in MoS2 monolayer, Seyyedeh Azar Oliaei Motlagh[1], Jhih-Sheng Wu[1], Vadym Apalkov[1], Mark Stockman[1]; [1]*Georgia State Univ., USA.* In MoS2 monolayer, we predict that a single oscillation femtosecond laser pulse with circular polarization creates a chiral distribution of conduction band electron population. This chirality is an effect of topological resonances in this semiconductor.

JTu4M.4 • 18:00
Carrier-Envelope Phase Detection with Arrays of Electrically Connected Bowtie Nanoantennas, Phillip D. Keathley[1], Yujia Yang[1], William Putnam[2], Praful Vasireddy[1], Franz Kärtner[1,3], Karl Berggren[1]; [1]*Massachussetts Inst. of Technology, USA;* [2]*NG Next, Northrop Grumman Coorporation, USA;* [3]*Center for Free Electron Laser Science and DESY, Germany.* We use arrays of electrically connected bowtie nanoantennas to detect the carrier-envelope phase of few-cycle optical pulses with noise performance close to the shot-noise limit. Our results pave the way towards low-cost, low-profile CEP monitoring and tagging.

17:00–19:00
STu4N • Semiconductor-Based Optical Frequency Combs
Presider: Ben Williams; UCLA, USA

STu4N.1 • 17:00 Tutorial
Quantum Cascade Frequency Combs: Physics and Applications, Jérôme Faist[1]; [1]*ETH Zurich, Switzerland.* Quantum cascade lasers combs have demonstrated watt level emission over 100cm^{-1} in the mid-infrared, enabling new applications such as spectroscopy protein reaction dynamics. New insight in their physics has recently been gained.

Jérôme Faist has obtained his Ph.D from EPFL, and has worked successively at IBM Rüschlikon, AT&T Bell Laboratories and the University of Neuchatel. He now holds a chair in the physics department of the ETH Zurich.

STu4N.2 • 18:00
Optomechanical Control of the State of Chip-Scale Frequency Combs, David P. Burghoff[1,2], Ningren Han[1,3], Filippos Kapsalidis[4], Nathan Henry[5], Mattias Beck[4], Jacob Khurgin[5], Jerome Faist[4], Qing Hu[1]; [1]*MIT, USA;* [2]*Univ. of Notre Dame, USA;* [3]*Google, USA;* [4]*ETH Zurich, Switzerland;* [5]*Johns Hopkins Univ., USA.* Quantum cascade laser frequency combs have substantial potential in sensing. We show that by blending them with microelectromechanical comb drives, one can directly manipulate the dynamics of the laser and fully control the comb state.

17:00–19:00
STu4O • Infrared Photonics & Applications
Presiders: Nan Zhang; State University of New York at Buffalo, USA
Haomin Song; State University of New York at Buffalo, USA

STu4O.1 • 17:00
Compact, ultra-tunable InGaSb/AlGaAsSb Si external cavity laser at the Mid-Infrared (MIR), Sia J. Brian[1], Wanjun Wang[1], Zhongliang Qiao[1], Xiang Li[1], Xin Guo[1], Jin Zhou[1], Zecen Zhang[1], Callum Littlejohns[2,1], Chongyang Liu[1], Graham T. Reed[2,1], Hong Wang[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Optoelectronics Reserch Centre, Univ. of Southampton, UK.* We present the first MIR hybrid Si external cavity laser with a tunable range below the 2 μm mark. To the best of our knowledge, we have achieved the largest tunable range of 66 nm (1881-1947 nm) near the 2 μm waveband in silicon photonics.

STu4O.2 • 17:15
Withdrawn

STu4O.3 • 17:30
Photonic Integrated Si_3N_4Ultra-Large-Area Grating Waveguide MOT Interface for 3D Atomic Clock Laser Cooling, Nitesh Chauhan[1], Debapam Bose[1], Matthew Puckett[2], Renan Moreira[1], Karl Nelson[2], Daniel Blumenthal[1]; [1]*Univ. of California, Santa Barbara, USA;* [2]*Honeywell, USA.* We describe a silicon nitride (Si_3N_4) photonic integrated circuit (PIC) designed to deliver non-diverging 780nm free-space optical cooling beams to an ^{87}Rb atomic magneto optic trap (MOT) via fiber coupled ultra-large-area 3.88mm x 2.08mm gratings.

STu4O.4 • 17:45
2.3 μm Wavelength Range Digital Fourier Transform on-Chip Wavelength Monitor, Anton Vasiliev[1,2], Fabio Pavanello[1,2], Muhammad Muneeb[1,2], Gunther Roelkens[1,2]; [1]*Photonics Research Group, Ghent Univ. - imec, Belgium;* [2]*Center for Nano- and Biophotonics, Belgium.* We present a novel approach for on-chip wavelength monitoring based on a digital Fourier Transform spectrometer. We demonstrate 130 nm operational bandwidth and an accuracy of 100 pm in the 2.3 μm wavelength range.

STu4O.5 • 18:00 Invited
Ge-rich SiGe Photonic Circuits for Mid IR spectroscopy, Delphine Marris-Morini[1]; [1]*Universite de Paris-Sud, France.* Ge-rich SiGe photonic circuits have been used to demonstrate a whole set of devices in the mid-IR, such as interferometers, spectrometers or cavities. The perspectives towards the realization of optical sources will be also presented.

NOTES

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C

Joint

CLEO: QELS-Fundamental Science

JTu4A • Symposium on Quantum Information in Time-Frequency Domain II—Continued

JTu4A.4 • 18:30
Photonic Controlled-PHASE Gate using Dynamic Cavities and a Kerr Nonlinearity, Mikkel Heuck[1,2], Kurt Jacobs[3,4], Dirk R. Englund[2]; [1]*Danmarks Tekniske Universitet, Denmark;* [2]*Dept. of Electrical Engineering and Computer Science, MIT, USA;* [3]*Computational and Information Sciences Directorate, U.S. Army Research Lab, USA;* [4]*Dept. of Physics, Univ. of Massachusetts at Boston, USA.* We propose a photonic CPHASE gate based on Kerr nonlinearities and tunable cavities enabling complete absorption and re-emission of photons. Storing photons about 40 times the width of their wavepackets results in 99% gate fidelity.

JTu4A.5 • 18:45
Exploring Quantum Memory via Optically Induced Bragg Structures, Carlo Page[1], Tom Weaver[1], John Price[2], Joshua Nunn[1]; [1]*Univ. of Bath, UK;* [2]*QOLS, Blackett Lab, Imperial College, UK.* We investigate short-term light storage for quantum computing by trapping light in an optically induced Bragg grating in warm Rb vapour.

FTu4B • Manipulation of Symmetries in Optics—Continued

FTu4B.6 • 18:30
Controlling Optical Forces between Evanescently Coupled PT-Symmetric Waveguides, Mohammad-Ali Miri[1,2], Michele Cotrufo[3], Andrea Alu[3,2]; [1]*Queens College of CUNY, USA;* [2]*Physics Program, The Graduate Center of CUNY, USA;* [3]*Advanced Science Research Center of CUNY, USA.* We investigate optical forces between evanescently coupled optical waveguides with balanced gain and loss. This system reveals unusual properties, most notably the emergence of a tangential stress component parallel to the direction of wave propagation.

FTu4B.7 • 18:45
Spatially locked mode in defected microring resonators, Hwaseob Lee[1], Tiantian Li[1], Zi Wang[1], Anishkumar Soman[1], Alec Scallo[1], Tingyi Gu[1]; [1]*Univ. of Delaware, USA.* Control of mode-splitting in a microring resonator is achieved by introducing notched scatters on its perimeter. Single step etching on SOI substrate enables the microring resonator to operate at exceptional point.

FTu4C • Nanophotonic Platforms for Optical Computing & Deep Learning—Continued

FTu4C.4 • 18:15
Application of deep learning to direct and inverse problems in plasmonic coloring, Joshua Baxter[1,2], Antonino Cala' Lesina[1,2], Jean-Michel Guay[1,2], Arnaud Weck[2,3], Pierre Berini[1,2], Lora Ramunno[1,2]; [1]*Physics, Univ. of Ottawa, Canada;* [2]*Center for Research in Photonics, Univ. of Ottawa, Canada;* [3]*Mechanical Engineering, Univ. of Ottawa, Canada.* Laser pulses can color noble metals by inducing nanoparticles on their surface. We apply deep learning to solve the direct and inverse problems which link nanoparticle distributions and laser parameters to the produced colour.

FTu4C.5 • 18:30
Gb/s physical random bits through mesoscopic chaos in integrated silicon optomechanical cavities, Ciwei Luo[1], Jaime G. Flor Flores[2], Binglei Shi[1], Mingbin Yu[3], Guoqiang Lo[3], Jia-Gui Wu[1,2], Chee Wei Wong[2]; [1]*Southwest Univ., China;* [2]*Fang Lu Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA;* [3]*The Inst. of Microelectronics, 11 Science Park Road, Singapore.* We present a silicon-based physical random bits (PRBs) generator, where mesoscopic chaos comes from coupled material nonlinearities and optomechanical oscillation have been used to generate fast (1.25Gbit/s) PRBs, which successfully passed NIST-SP800-22 standard randomness tests.

17:30-18:30 OSA Senior Member Reception, *OSA Member Lounge, Concourse Level*

19:00–20:30 OSA Technical Group Poster Session, *Grand Ballroom 220C*

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTu4D • Thermal Photonics—Continued

FTu4D.5 • 18:15
Perfect selective emitter with far infrared photonic structure, Se-Yeon Heo[1], Gil Ju Lee[1], Young Min Song[1]; [1]*Gwangju Inst. of Science and Technol, South Korea (the Republic of).* We design and fabricate metasurface radiative cooler, in which high emissivity is achieved over the full range of main transparency window. The results provide one potential route to the absorption tuning at far infrared wavelength.

FTu4D.6 • 18:30
Incoherent Perfect Absorption in Lossy Dielectric Media, Sanjay Debnath[1], Evgenii E. Narimanov[1]; [1]*Purdue Univ., USA.* We theoretically demonstrate perfect absorption of incoherent light in lossy anisotropic half-infinite planar dielectric structures, and uncover this effect in existing (meta) materials.

FTu4D.7 • 18:45
All-Dielectric Metalens Integrated with Dispersive Grism for High Spectral Resolution at Mid-Infrared Regime, Semih Cakmakyapan[1], Yi-Chun Ling[1], Mathias Prost[1], S.J.Ben Yoo[1]; [1]*UCD, USA.* We present a proof-of-concept beam steering device which resolves the wavelength differences at mid-infrared regime by utilizing an all-dielectric metalens structure integrated with a grism structure.

Executive Ballroom 210E / Executive Ballroom 210F

CLEO: Science & Innovations

STu4E • High Peak-Power Laser & Technologies II—Continued

STu4E.5 • 18:15
A methodology for designing grism stretchers for idler-based optical parametric chirped-pulse amplification systems, Sara Bucht[1], Dan Haberberger[1], Jake Bromage[1], Dustin Froula[1]; [1]*Lab for Laser Enegetics, USA.* This paper presents a method for designing grism stretchers and grating compressors that can produce near transform-limited idler pulses from OPCPA systems.

STu4E.6 • 18:30
Pulse Contrast Enhancement via Non-collinear Sum-Frequency Generation of the Signal and Idler of an Optical Parametric Amplifier, Eric Cunningham[1], Eric Galtier[1], Gilliss Dyer[1], Joseph Robinson[1], Alan Fry[1]; [1]*SLAC National Accelerator Lab, USA.* We improve the temporal contrast of the front end of a high-intensity laser system to better than twelve orders of magnitude using non-collinear sum-frequency generation of the signal and idler of an optical parametric amplifier.

STu4F • Terahertz Spectroscopy—Continued

STu4F.6 • 18:30
Thickness-Dependent THz Emission From Ultrathin Ferrimagnetic $Mn_{3-x}Ga$ Films, Igor Ilyakov[1], Nilesh Awari[1,3], Sergey Kovalev[1], Ciarán Fowley[1], Karsten Rode[2], Plamen Stamenov[2], Yong Chang Lau[2], Davide Betto[2], Nivetha Thiyagarajah[2], Bertram Green[1], Oguz Yildirim[1], Jürgen Lindner[1], Jürgen Fassbender[1], Michael Coey[2], Alina Deac[1], Michael Gensch[1]; [1]*Helmholtz-Zentrum Dresden-Rossendorf, Germany;* [2]*Trinity College Dublin, Ireland;* [3]*Univ. of Groningen, Netherlands.* An experimental time-domain, room-temperature study of magnetization precession in ultra-thin $Mn_{3-x}Ga$ films excited by femtosecond laser pulses is presented. The thickness dependence of the parameters of THz waves emitted from coherently driven magnetic resonances is investigated.

STu4F.7 • 18:45
Monitoring Charge Separation Dynamics Using THz Emission Spectroscopy, Burak Guzelturk[1,4], Eric Yue Ma[2,4], Guoqing Li[3], Linyou Cao[3], Zhi-Xun Shen[2], Tony Heinz[2,4], Aaron Lindenberg[1,4]; [1]*Materials Science and Engineering, Stanford Univ., USA;* [2]*Dept. of Applied Physics, Stanford Univ., USA;* [3]*Dept. of Materials Science and Engineering, North Carolina State Univ., USA;* [4]*Stanford Inst. for Materials and Energy Sciences, SLAC, USA.* We present terahertz (THz) emission spectroscopy as a means of monitoring ultrafast charge separation dynamics in layered two-dimensional heterostructures.

17:30-18:30 OSA Senior Member Reception, *OSA Member Lounge, Concourse Level*

19:00–20:30 OSA Technical Group Poster Session, *Grand Ballroom 220C*

CLEO: Science & Innovations

STu4G • Miniaturizing Quantum Technology—Continued

STu4G.3 • 18:30
Alkali metal condensation zones in MEMS alkali vapor cells and characterization in CPT clock, Sylvain Karlen[1], Thomas Overstolz[1], Jean Gobet[1], Jacques Haesler[1], Fabien Droz[1], Steve Lecomte[1]; [1]*CSEM SA, Switzerland.* We fabricated MEMS vapor cells gold microdiscs, allowing the condensation of alkali metal on preferred locations without the use of a thermal gradient. Reduction of light-shift induced long-term frequency instability in CPT clock is reported.

STu4G.4 • 18:45
Nanophotonic Integration of Atomic Wavelength References, Douglas Bopp[1], John Kitching[1], Vladimir Aksyuk[1]; [1]*NIST, USA.* Nanophotonic circuitry is interfaced to microfabricated alkali vapor cells forming a quantum sensing platform. We operate this device as a wavelength reference using several operation modes and discuss strengths and limitations of such devices.

STu4H • Innovations in Machine Learning & Microscopy—Continued

STu4H.5 • 18:15
Smartphone-based cancer detection platform based on plasmonic interferometer array biochips, Xie Zeng[1], Yunchen Yang[1], Nan Zhang[1], Dengxin Ji[1], Yun Wu[1], Qiaoqiang Gan[1]; [1]*State Univ. of New York at Buffalo, USA.* We develop a nanoplasmonic interferometer imaging system based on intensity modulation to detect circulating exosomal proteins in real-time with high sensitivity and low cost to enable the early detection of cancer.

STu4H.6 • 18:30
Multicolor Stimulated Raman and Fluorescence Imaging with High-speed Programmable Tunability, Jingwen Shou[1], Robert Oda[1,2], Shunji Tanaka[1], Yasuyuki Ozeki[1]; [1]*Univ. of Tokyo, Japan;* [2]*The Univ. of Hawaii, USA.* We demonstrate a multispectral and multimodal microscopy which enables high-speed stimulated Raman and fluorescence imaging. Both the Raman wavenumber and the fluorescence detection wavelength of each frame can be tuned via high-speed galvanometer-driven optical filters.

STu4H.7 • 18:45
Intracellular GaN microrod laser, Minho Song[1], Hyeonjun Baek[2], Gyu-Chul Yi[1]; [1]*Seoul National Univ., South Korea (the Republic of);* [2]*Heriot-Watt Univ., UK.* We report fabrication of GaN microrods and their intracellular lasing characteristics for individual cell tracking and labeling application.

CLEO: Applications & Technology

ATu4I • Emerging Lasers for Device Fabrication—Continued

ATu4I.5 • 18:30
>300-W femtosecond laser with free triggering up to 25 MHz, Florent Basin[1], Julien Pouysegur[1], Martin Delaigue[1], Benoit Tropheme[1], Jorge Sanabria[1], Eric Mottay[1], Clemens Hoenninger[1]; [1]*Amplitude Laser Group, France.* We demonstrate a high power femtosecond laser with up to 500-W and 400-fs pulse width. A unique free-triggering option enables arbitrary pulse train control with unprecedented speed of 25MHz and timing jitter of only 10ns.

ATu4I.6 • 18:45
All-Fiber 2 µm Amplifier Using A Normal Dispersion Thulium Fiber, Yuhao Chen[1], Shaoxiang Chen[1], Kun Liu[1], Qijie Wang[1], Dingyuan Tang[1], Seongwoo Yoo[1]; [1]*Nanyang Technological Univ., Singapore.* Normal dispersion thulium-doped fiber was deployed in all-fiber setup to amplify pulses from a near-2 µm ultrafast fiber ring cavity and demonstrated >27 dB amplification without pulse breaking. Output pulse energy ~525nJ reported at 1852nm.

17:30-18:30 OSA Senior Member Reception, *OSA Member Lounge, Concourse Level*

19:00–20:30 OSA Technical Group Poster Session, *Grand Ballroom 220C*

Meeting Room 211 C/D

CLEO: Science & Innovations

STu4J • Quantum Nanostructure—Continued

STu4J.6 • 18:30
Heterogeneous integrated quantum photonic devices with single, deterministically positioned InAs quantum dots, Peter Schnauber[2], Anshuman Singh[1,3], Johannes Schall[2], Sven Rodt[2], Kartik Srinivasan[1], Stephan Reitzenstein[2], Marcelo I. Davanco[1]; [1]*NIST, USA;* [2]*Inst. of Solid-State Physics, Technical Univ. of Berlin, Germany;* [3]*Maryland NanoCenter, Univ. of Maryland, USA.* We demonstrate integrated Si3N4 waveguides containing single-photon emitters based on single InAs quantum dots that were deterministically positioned in a GaAs nanowaveguide via a low-temperature in-situ electron-beam lithography.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATu4K • Biosensing Technology—Continued

ATu4K.5 • 18:15
Cost-effective, CMOS-compatible, label-free biosensors using doped silicon detectors and a broadband source, Leanne Dias[1], Enxiao Luan[1], Hossam Shoman[1], Hasitha Jayatilleka[1], Sudip Shekhar[1], Lukas Chrostowski[1], Nicolas Jaeger[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of British Columbia, Canada.* By replacing Ge-based photodetectors and tunable lasers with doped silicon photoconductive heaters/detectors and broadband sources, we propose and demonstrate a cost-effective implementation of photonic sensors for biosensing applications.

ATu4K.6 • 18:30
Deep Learning Enables Virtual Histological Staining of Label-free Tissue Sections Using Auto-fluorescence, Yair Rivenson[1], Hongda Wang[1], Kevin de Haan[1], Zhensong Wei[1], Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* We report a data-driven method for label-free virtual histological staining of tissue sections using deep learning. This framework is successfully demonstrated by inferring multiple types of stains on different tissue types using auto-fluorescence signal.

ATu4K.7 • 18:45
Smart Mattress System Based on Interferometric Fiber Optics for Vital Signs Monitoring, Senmao Wang[1], Lliangye Li[1], Jingyi Wang[1], Zhijun Yan[1], Deming Liu[1], Qizhen Sun[1]; [1]*Huazhong Univ of Science and Technology, China.* A smart mattress system is developed to monitor human vital signs. The heart rate signal and respiration signal are measured simultaneously by the system based on fiber optic Mach-zender interferometer.

Meeting Room 212 C/D

CLEO: Science & Innovations

STu4L • Mode-Locked Fiber Lasers II—Continued

STu4L.5 • 18:15
Passive Elimination of Spectrally Correlated Intensity Noise in Ultrabroadband Supercontinua from Highly Nonlinear Fibers, Philipp Sulzer[1], Andreas Liehl[1], Kilian R. Keller[1], Jeldrik Huster[1], Cornelius Beckh[1], Alfred Leitenstorfer[1]; [1]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany.* Amplitude fluctuations of pump pulses for frequency broadening by third-order processes are found to result in strong anti-correlations of spectral output components. We exploit this information to minimize intensity noise in subsequent nonlinear conversion steps.

STu4L.6 • 18:30
Resolving the temporal structure of noise-like pulse using a synchronized time magnifier, Bowen Li[1], Jiqiang Kang[1], Sheng Wang[1], Ying Yu[1], Pingping Feng[1], Kenneth Kin-Yip Wong[1]; [1]*Univ. of Hong Kong, Hong Kong.* The detailed temporal structures inside the noise-like pulses have been resolved in real time for the first time using a synchronized parametric time magnifier. Optical rogue waves have been observed under sub-ps temporal resolution.

STu4L.7 • 18:45
Spectrally uniform discrete Fourier domain mode locked fiber laser by time domain modulation, Dongmei Huang[1], Chao Shang[2], Feng Li[1], Xianting Zhang[1], Zihao Cheng[1], Jinhui Yuan[1], Xinhuan Feng[3], P. K. A. Wai[1]; [1]*The Hong Kong Polytechnic Univ., Hong Kong;* [2]*The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China;* [3]*Jinan Univ., China.* We propose and demonstrate a frequency domain linearized discrete Fourier domain mode locked laser with a rate varying pulse modulation in time domain. Discrete swept signal with an identical FSR of 100 GHz is demonstrated.

17:30-18:30 OSA Senior Member Reception, *OSA Member Lounge, Concourse Level*

19:00–20:30 OSA Technical Group Poster Session, *Grand Ballroom 220C*

Marriott Salon I & II	Marriott Salon III	Marriott Salon IV
Joint	CLEO: Science & Innovations	

JTu4M • Symposium on Intense-field Nonlinear Optics & High Harmonic Generation in Nanoscale Materials II—Continued

JTu4M.5 • 18:15
Circular dichroism of electrons photoemitted from an emitter array of Au nanospirals, Hong Ye[1,2], Anchita Addhya[1,3], Sebastian Trippel[1,4], Arya Fallahi[1], Subir Ray[3], Nirmalya Ghosh[3], Oliver D. Mücke[1,4], Jochen Küpper[1,2], Franz Kärtner[1,2]; *[1]DESY/CFEL, Germany; [2]Univ. of Hamburg, Germany; [3]Indian Inst. of Science Education and Research Kolkata,, India; [4]The Hamburg Centre for Ultrafast Imaging, Germany.* We have investigated photoemission from an emitter array of Au nanospirals on an ultrafast time scale via velocity-map-imaging (VMI) spectroscopy. Circular dichroism of the velocity distribution of the emitted electrons is observed.

JTu4M.6 • 18:30 Invited
Optical Harmonic Generation in Nonlinear All-Dielectric Nanoantennas and Metasurfaces, Andrey Fedyanin[1]; *[1]Lomonosov Moscow State Univ., Russia.* We present recent experimental results of controllable optical harmonic generation in all-dielectric nanoantennas and metasurfaces fabricated from direct (silicon) and indirect (gallium arsenide) semiconductor nanoparticles possessing low-order Mie-resonances in visible and IR ranges.

STu4N • Semiconductor-Based Optical Frequency Combs—Continued

STu4N.3 • 18:15
Optical-feedback-stabilized quantum cascade laser frequency combs, Chu Teng[1], Jonas Westberg[1], Gerard Wysocki[1]; *[1]Princeton Univ., USA.* Stabilization of quantum-cascade-laser frequency combs by means of external optical feedback is presented. Experimental results suggest reduced phase-noise in the frequency comb, allowing comb operation in previously unstable regimes.

STu4N.4 • 18:30
Narrow Intrinsic Linewidth Frequency Combs from a Chip-Based Hybrid Integrated InP-Si_3N_4 Diode Laser, Jesse Mak[1], Albert v. Rees[1], Youwen Fan[1], Edwin J. Klein[2], Dimitri Geskus[2], Peter van der Slot[1], Klaus J. Boller[1]; *[1]Univ. of Twente, Netherlands; [2]LioniX International BV, Netherlands.* We present a hybrid integrated InP-Si_3N_4 laser that generates frequency combs with a record-low intrinsic linewidth of 34 kHz.

STu4N.5 • 18:45
Performance of an injection-locked active demultiplexer for FSR-tunable optical frequency combs, Prajwal Doddaballapura Lakshmijayasimh[1], Eamonn Martin[1], Seán P. Ó Duill[1], Pascal Landais[1], Prince M. Anandarajah[1], Aleksandra Kaszubowska-Anandarajah[2]; *[1]School of Electronics Engineering, Dublin City Univ., Ireland; [2]Trinity College Dublin, CONNECT Research Centre, Ireland.* An active injection-locked demultiplexer for optical combs with flexible channel spacing is demonstrated. Relationships between the injected power and frequency detuning of a 6.25GHz comb and the output comb suppression and phase noise are characterized.

STu4O • Infrared Photonics & Applications—Continued

STu4O.6 • 18:30
Interband cascade laser frequency combs for monolithic and battery driven spectrometers, Benedikt Schwarz[3], Johannes Hillbrand[3], Maximilian Beiser[3], Aaron M. Andrews[3], Gottfried Strasser[3], Hermann Detz[1,3], Anne Schade[2], Robert Weih[4], Sven Höfling[2]; *[1]CEITEC, Czechia; [2]Univ. Würzburg, Germany; [3]TU Wien, Austria; [4]Nanoplus, Germany.* We demonstrated a monolithic frequency comb platform based on interband cascade lasers. We show self-starting frequency combs operation utilizing the inherent gain non-linearity and exceptionally fast and sensitive room-temperature photodetection to enable on-chip multi-heterodyne detectors.

STu4O.7 • 18:45
Integrated DFB Lasers on Si_3N_4 Photonic Platform for Chip-Scale Atomic Systems, Kevin F. Gallacher[1], Martin Sinclair[1], Ross Millar[1], Oliver Sharp[2], Francesco Mirando[2], Gary Ternent[2], Gordon Mills[2], Brendan Casey[2], Douglas J. Paul[1]; *[1]Univ. of Glasgow, UK; [2]Kelvin Nanotechnology, UK.* 780 nm wavelength distributed feedback lasers have been integrated onto a Si_3N_4 photonic platform on a Si substrate and coupled into waveguides for laser locking to either a ring resonator or rubidium vacuum cell.

17:30-18:30 OSA Senior Member Reception, *OSA Member Lounge, Concourse Level*

19:00–20:30 OSA Technical Group Poster Session, *Grand Ballroom 220C*

NOTES

07:30–18:30 Registration, *Concourse Level*

08:00–10:00 JW1A • Joint Plenary Session, *Grand Ballroom 220A*

10:00–17:00 Exhibit Open (10:00–17:00), Coffee Break (10:00–11:30), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

10:30–12:00 MIRTHE: New Commercial Trends in Mid-Infrared Sensing – From Nano-Photonics to Stand-Off Detection, *Exhibit Hall Theater I*

10:30–12:00 Beyond Awareness: What Actions Can Be Taken to Improve Diversity in STEM, *Exhibit Hall Theater II*

Exhibit Halls 1-3

11:30–13:00 JW2A • Poster Session I and Lunch

JW2A.1
Digital Holography for Local Heat Flux Measurement along the Surface of Heated Wire, Varun Kumar[1], Chandra Shakher[1]; [1]*Indian Inst. of Technology Delhi, India.* In this paper, local heat flux Q(y) and convective heat transfer coefficient (h_c) is measured along the surface of electrically heated wire using digital holographic interferometry (DHI). Experiments were performed on tungsten wire of different diameters.

JW2A.2
LMD-ICA Based Intrusion Even Positioning Algorithm for φ-OTDR Fiber Optic Perimeter Security System, Yuzhao Ma[1], Wantong Zhang[1], Xinglong Xiong[1]; [1]*Civil Aviation Univ. of China, China.* In the paper we proposed a novel algorithm based on the LMD-ICA method, in order to improve the performance of the intrusion event positioning of theφ-OTDR fiber optic perimeter security system.

JW2A.3
Hybrid Square/Rhomb-Rectangular Semiconductor Lasers for Ethylene Detection, Zhengzheng Shen[1], YouZeng Hao[1], Fuli Wang[1], Ke Yang[1], Hongyan Yu[1], Jiaoqing Pan[1], YueDe Yang[1], Jin-Long Xiao[1], YongZhen Huang[1]; [1]*Inst. of Semiconductors, CAS, China.* We present a tunable hybrid square/rhomb-rectangular AlGaInAs/InP semiconductor laser for ethylene detection. Single-mode lasing around 1.626 μm is achieved with a side mode suppression ratio above 30 dB and an output power over 1 mw.

JW2A.4
Testing of an Optomechanical Accelerometer with a High-Finesse On-Chip Microcavity, Feng Zhou[1]; [1]*NIST, USA.* The motion of a microresonator integrated in a silicon hemisphere Fabry-Perot microcavity is used to transduce acceleration. We present the prototype assembly and performance tests of the optomechanical accelerometer.

JW2A.5
Development of Path-integrated Remote Chirped Laser Dispersion Spectrometer with Automatic Target Tracking , Michael G. Soskind[1], Yifeng Chen[1], Gerard Wysocki[1]; [1]*Princeton Univ., USA.* The recent developments in instrumentation for mobile field deployment of a chirped laser dispersion spectroscopy is discussed, including optomechanical considerations, system signal fidelity, and real-time target tracking for chemical plume detection.

JW2A.6
Transparent diffraction gratings using silicon nanowire arrays embedded in flexible polymer , YeongJae Kim[1], Young Jin Yoo[1], Young Min Song[1]; [1]*Gwangju Inst. of Science and Technol, South Korea (the Republic of).* Two dimensional diffraction gratings was demonstrated by using vertical silicon nanowire arrays in transparent and flexible polymer. The high order diffraction was observed by controlling their shapes of the silicon nanowire arrays.

JW2A.7
Experimental demonstration of Vehicle-borne Near Infrared Three-Dimensional Ghost Imaging LiDAR, Xiaodong Mei[2,1], Chenglong Wang[2,1], Long Pan[2,1], Pengwei Wang[2,1], Wenlin Gong[2], Shensheng Han[2]; [1]*Univ. of Chinese Academy of Sciences, China;* [2]*Key Lab for Quantum Optics and Center for Cold Atom Physics of CAS, Shanghai Inst. of Optics and Fine Machines,Chinese Academy of Sciences, China.* We propose a Vehicle-borne near infrared 3D ghost imaging LiDAR. The experimental results demonstrate that the image of target at 120m range with 30mm resolution can be obtained when the vehicle's speed is 30km/h.

JW2A.8
Tunable Light Source with LDLS and AOTF, Xiaohua Ye[1], Alex Culter[1], Ron Collins[1], Debbie Gustafson[1], Huiling Zhu[1]; [1]*Energetiq Inc., USA.* Performances of a tunable light source (TLS) using an acousto-optic tunable filter (AOTF) and a Laser-Driven Light Source (LDLS™) are evaluated. Experimental results of in-band fluxes, FWHM bandwidths between 400nm and 800nm, are presented.

JW2A.9
Dual-parameter sensing based on Fano resonances by a nanobeam cavity side-coupled to a defect waveguide, Zheng Wang[1], Jian Zhou[1], Zhongyuan Fu[1], Fujun Sun[1], Chao Wang[1], Xuepei Li[1], Huiping Tian[1]; [1]*Beijing Univ of Posts & Telecom, China.* We propose a dual-parameter sensor based on multiple Fano resonance modes. Both the sensor matrix and the detection error analysis are investigated. This compact sensor is promising in high-performance lab-on-chip and label-free detection system.

JW2A.10
Stokes polarimeter with polarization-dependent hologram, Hailong Zhou[1], Yanxian Wei[1], Yu Yu[1], Jianji Dong[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, China.* A Stokes polarimeter is demonstrated with polarization-dependent hologram. Owing to the low demand on the pattern of hologram, our work offer an easily manufactured scheme to measure the polarization of the light.

JW2A.11
Advanced Spectrometer with Two Spectral Channels Sharing the Same BSI-CMOS Detector, Liang-Yao Chen[1], Kai-Yan Zang[1], Yuan Yao[1], Er-Tao Hu[1], An-Qing Jiang[2], Yu-Xiang Zheng[1], Song-You Wang[1], Hai-Bin Zhao[1], Yu-Mei Yang[1], Osamu Yoshie[2], Young-Pak Lee[3], David Lynch[4]; [1]*Fudan Univ., China;* [2]*Waseda Univ., Japan;* [3]*Hanyang Univ., South Korea (the Republic of);* [4]*Iowa State Univ., USA.* By consisting of 8 sub-gratings to image two sets of 4-folded spectra on the focal plane of a BSI-CMOS detector, a two-channel spectrometer with a resolution of better than 0.1 nm/pixel in the 200- 950-nm spectral range is studied with the result measured for the Hg-Ar lamp.

JW2A.12
SI-traceable Calibration of Suitcase SOLARIS for CLARREO Pathfinder Mission, Yigit Aytac[1], Kurtis Thome[2], Brian Wenny[1], Timony M. Shuman[3], Julia Barsi[1], Brendan McAndrew[4], Barbara J. Zukowski[5], Amit Angal[1], Joel McCorkel[2]; [1]*Science Systems and Applications, Inc., USA;* [2]*Biospheric Sciences, NASA Goddard Space Flight Center, USA;* [3]*Fibertek, USA;* [4]*NASA Goddard Space Flight Center, USA;* [5]*Ball Aerospace, USA.* NASA's high accuracy calibration system GLAMR is utilized for testing a portable, visible and near-IR version of an imaging spectrometer that is part of the CLARREO Pathfinder mission to help demonstrate that 0.3% absolute uncertainty in reflectance retrieval is achievable.

JW2A.13
Superluminal Laser Gravitational Wave Detector, Minchuan Zhou[1], Zifan Zhou[1], Selim M. Shahriar[1]; [1]*Northwestern Univ., USA.* We propose a gravitational wave detector that uses two superluminal lasers. Compared to the Advanced LIGO detector, the range for detecting binary neutron star inspirals is enhanced by a factor of 19 using this scheme

JW2A.14
Detection of Rare-Earth Elements Enhanced by Bio-Metal-Organic Frameworks (MOFs) Using UV LED, Hui Lan[2], Scott Crawford[1], Zach Splain[1], Thomas Boyer[1], Paul Ohodnicki[3], Ran Zou[1], Mohan Wang[1], Kevin P. Chen[1]; [1]*Uniiversity of Pittsburgh, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Pittsburgh , USA;* [3]*U.S. Dept. of Energy, USA.* Spectral characteristics of BioMOF-sensitized trace rare-earth elements dissolved in water are studied at room temperature by laser-induced fluorescence method using a 280-nm LED. This paper presents a low-cost detection scheme toward extraction of rare-earth materials in liquid phase.

JW2A.15
White-Light Photothermal Mirror Spectrophotometer, Aristides Marcano Olaizola[1], May Hlaing[1]; [1]*Delaware State Univ., USA.* We describe an arc-lamp based pump-probe photothermal mirror spectrophotometer to measure the spectrum of the thermal quantum yield of the surface of solid samples. We discuss advantages of the method to characterize solid nontransparent materials.

JW2A.16
Microscale-patterned colored passive radiative cooler, Gil Ju Lee[1], Se-Yeon Heo[1], Young Min Song[1]; [1]*Gwangju Inst of Science & Technology, South Korea (the Republic of).* Thermal management in colored objects has been intensively attractive for a long time. The proposed scheme is based on micro-patterned metal-insulator-metal with thermal emission polymer, which can reduce the temperature of colored objects.

11:30–13:00 JW2A • Poster Session II and Lunch

JW2A.17
Double Al nanoparticle array for enhanced absorption in thin film GaAs solar cells, Gurjit Singh[1], S S. Verma[1]; [1]*Physics, Sant Longowal Inst. of Engineering and Technology, Longowal, India.* The effect of single and double Al nanoparticle array on absorption of thin film GaAs solar cells is investigated by FDTD method. Plasmonic action of double array yields a maximum absorption enhancement factor of 1.74.

JW2A.18
Multispecies Laser Diagnostic System for Vehicle Tailpipe Emission Measurements, Luigi Biondo[1], Oliver Diemel[1], Vadim Doberstein[1], Henrik Gerken[1], Lars Illmann[1], Michael Jonek[1], Marvin Schmidt[1], Tim Steinhaus[1], Steven Wagner[1]; [1]*Technische Universität Darmstadt, Germany.* A multispecies *in situ* TDLAS-system for simultaneous detection of NO, CO, CO_2, H_2O and NH_3 was applied at an engine test rig for exhaust gas measurements and results were compared to commercially available reference systems.

JW2A.19
High Efficiency InP Pillar Array Heterojunction Solar Cells, Lin Gan[1], Seyed Ebrahim Hashemi Amiri[2], Dong-Ying Li[2], Alan H. Chin[3], Yue-Yang Yu[2], Cun-Zheng Ning[1,2]; [1]*Tsinghua Univ., China;* [2]*Arizona State Univ., USA;* [3]*nLiten Energy Corporation, USA.* Nanopillars can enhance solar cell performance, but the increased surface recombination often cancels performance gains. We demonstrate suppression of surface recombination through passivation of InP-pillar heterojunction solar cells, achieving a very high efficiency of 18.31%.

JW2A.20
Off-Resonant Broadband Photoacoustic Spectroscopy for Online Monitoring of Biogas Concentration with a Wide Dynamic Range, Ramya Selvaraj[1], Nilesh J. Vasa[1], Shiva N. S M[1]; [1]*Indian Inst. of Technology, Madras, India.* Online measurement of CO_2 ,CH_4 and H_2O in a biogas plant using a Supercontinuum laser based off-resonant broadband photoacoustic spectroscopy is realized. The system exhibits a wide dynamic range from ppbv - 100% concentration.

JW2A.21
Near-infrared broadband cavity-enhanced sensor system for methane detection using a wavelet-denoising assisted Fourier-transform spectrometer, Kaiyuan Zheng[1], Chuan-Tao Zheng[1], Zidi Liu[1], Qixin He[1], Qiaoling Du[1], Yu Zhang[1], Yiding Wang[1], Frank Tittel[2]; [1]*Jilin Univ., China;* [2]*Rice Univ., USA.* We demonstrated a broadband cavity-enhanced sensor in the near-infrared range in combination with a wavelet-denoising assisted Fourier-transform spectrometer for high-resolution methane detection. A minimum detectable absorption coefficient of 4.6×10^{-7} cm^{-1} was achieved.

JW2A.22
Multi-harmonic detection of methane using 3.2 µm mid-IR DFB laser for environmental sensing applications, Caio Azevedo[1], Luil Menberu[1], Devonte Dowdard[1], May Hlaing[1], Mohammad A. Khan[1]; [1]*Delaware State Univ., USA.* We show advantages of higher harmonic 2f and 4f-wavelength modulation spectroscopic detection for improving sensitivity in methane detection. A spectral-line analysis in the wing region is used to achieve 1-sec. precision of 0.3% or 5 ppbv.

JW2A.23
Highly sensitive and robust refractive index sensing using a microfluidic chip with microfiber probe, Fang Fang[1], Junjie Wang[1], Yanpeng Li[1], Yuezhen Sun[1], Liuyang Yang[1], Jie Hu[1], Zhijun Yan[1], Qizhen Sun[1]; [1]*Huazhong Univ of Science and Technology, China.* A microfluidic chip with multimode microfiber probe for refractive index sensing is proposed and experimentally demonstrated. A high RI sensitivity of ~2169.64nm/RIU with a good linearity ranging from 1.335 to 1.341 is achieved.

JW2A.24
Role of Mixed-dimensional Excitons in the Phase Dynamics of Semiconductor Optical Lasers and Amplifiers, Bastian Herzog[1], Mirco Kolarczik[1], Sophia Helmrich[1], Kathy Lüdge[1], Ulrike K. Woggon[1], Nina Owschimikow[1]; [1]*Technische Universität Berlin, Germany.* We characterize the dynamic amplitude and phase response of InAs(Sb)/GaAs submonolayer quantum dots as active medium in opto-electronic devices. Mixed-dimensional excitons cause broadband emission and a large alpha parameter, promising for, e.g., chaotic lasing.

JW2A.25
Charge Carrier Dynamics in Conjugated Polymer – MoS_2 Organic-2D Heterojunctions, Christopher Petoukhoff[1], Sofiia Kosar[1], Ibrahim Bozkurt[2], Manish Chhowalla[2], Keshav M. Dani[1]; [1]*Okinawa Inst. of Science and Technol, Japan;* [2]*Materials Science and Engineering, Rutgers Univ., USA.* We investigate the charge transfer efficiency between 3 different conjugated polymer-MoS_2 heterojunctions using femtosecond transient absorption spectroscopy.

JW2A.26
Carrier Dynamics and Ultrafast Zero-bias Photocurrents in SnS_2 Single Crystals, Erin M. Morissette[1], Kateryna Kushnir[1], Curtis W. Doiron[2], Ronald L. Grimm[2], Lyubov V. Titova[1]; [1]*Physics, Worcester Polytechnic Inst., USA;* [2]*Chemistry and Biochemistry, Worcester Polytechnic Inst., USA.* The carrier dynamics of SnS_2 single crystals are investigated via terahertz spectroscopy for photovoltaic applications. Above-bandgap excitation generates long-lived free carriers with high mobility, and three-fold-symmetric THz generation suggests an ultrafast surface shift current.

JW2A.27
Coherent Oscillations in the Vibrational Modes of 1-Aminoanthraquinone and Solvent DMSO Manifest the Ultrafast Intramolecular Charge Transfer, Kooknam Jeon[1], Sebok Lee[1], Myungsam Jen[1], Yoonsoo Pang[1]; [1]*Gwangju Inst of Science & Technology, South Korea (the Republic of).* Ultrafast charge transfer of 1-aminoanthraquinone with the twist of NH_2 group in the excited state is clearly monitored by the coherent oscillations of the coupled vibrational modes of the solute and the surrounding solvent molecules.

JW2A.28
Probing ultrafast, shock-induced chemistry using extremely broadband, ultrashort mid-infrared pulses, Pamela R. Bowlan[1], Michael Powell[1], Romain Perriot[1], Enrique Martinez[1], Edward Kober[1], Marc Cawkwell[1], Shawn McGrane[1]; [1]*Los Alamos National Lab, USA.* Using extremely broad-band mid-infrared pulses (3-14 µm), and a single shot spectrometer, we probe ultrafast chemistry at high pressures (~20 GPa) through changes in the vibrational spectrum. Here we present results on shocked benzene and nitromethane.

JW2A.29
Exciton Diffusion in a Monolayer MoS_2-WS_2 Lateral Heterostructure, Jiahui Huang[1], Monica Lorenzon[2], Jin Ho Kang[1], Peng Chen[3], Xiangfeng Duan[3], Ed Barnard[2], Chee Wei Wong[1], Alexander Weber-Bargioni[2]; [1]*Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA;* [2]*Molecular Foundry, Lawrence Berkeley National Lab, USA;* [3]*Dept. of Chemistry, Univ. of California, Los Angeles, USA.* In this paper, we observed preliminary exciton diffusion signature in a WS_2-MoS_2 lateral heterostructure at room temperature. Within center MoS_2 the diffusion appears to be 300 nm, along the WS_2-MoS_2 edge the diffusion appears to be more than 2µm.

JW2A.30
Population relaxation and coherence times of $^{167}Er^{3+}$ diluted to 10 ppm in Y_2SiO_5 at zero magnetic field, Masaya Hiraishi[1,2], Mark IJspeert[1], Takehiko Tawara[1,2], Hiroo Omi[1], Hideki Gotoh[1]; [1]*NTT Basic Research Labs, Japan;* [2]*Tokyo Univ. of Science, Japan.* We investigate population relaxation and optical coherence times in isotopically purified $^{167}Er^{3+}$ diluted to 10 ppm in Y_2SiO_5 at zero magnetic-field. It reveals long relaxation time of 130 ms and coherence time of 12 µs.

JW2A.31
Revealing Exciton Dissociation and Inhomogeneity in Metal Halide Perovskite Thin Films, Geoffrey M. Diederich[1], Mark Siemens[1]; [1]*Univ. of Denver, USA.* We present multidimensional spectra of excitons in formamidinium-methylammonium lead triiodide perovskite films at low temperature. The spectra show inhomogeneous broadening and two distinct states, which we assign to free and defect-bound excitonic states.

JW2A.32
Ultrafast Photoluminescence without Phonon Scattering Due to Nonlocal Light-Matter Interaction, Masayoshi Ichimiya[1,3], Takuya Matsuda[2], Hajime Ishihara[1,2], Masaaki Ashida[1]; [1]*Osaka Univ., Japan;* [2]*Osaka Prefecture Univ., Japan;* [3]*The Univ. of Shiga Prefecture, Japan.* Ultrafast radiative recombination of confined excitons in a semiconductor mesoscopic thin film has been investigated by temperature dependence of photoluminescence spectra. Sub-100 fs radiative decay competes with phonon scattering even at room temperature.

JW2A.33
Electrical Manipulation of the Valley Polarization and Valley Coherence in a van der Waals Heterostructure, Arunabh S. Mukherjee[2], Chitraleema Chakraborty[1,3], Liangyu Qui[2], Anthony Vamivakas[2]; [1]*Electrical Engineering and Computer Science, MIT, USA;* [2]*The Inst. of Optics, Univ. of Rochester, USA;* [3]*Material Science, Univ. of Rochester, USA.* Valley contrasting polarization selection rules present unique opportunities for optical control in valleytronic devices. In this work, we demonstrate the electric-field control of both valley polarization and valley coherence of excitons in a monolayer semiconductor.

JW2A.34
High-mobility indirect excitons in a wide single quantum well heterostructure, Chelsey Dorow[1], Darius J. Choksy[1], Matt Hasling[1], Jason Leonard[1], Michael Fogler[1], Leonid Butov[1], Kenneth West[2], Loren Pfeiffer[2]; [1]*Univ. of California San Diego, USA;* [2]*Princeton Univ., USA.* We present wide single quantum well (WSQW) heterostructures and the achievement of record-high mobility of indirect excitons (IXs). WSQW heterostructures provide low-disorder platform both for exploring basic IX properties and for developing high-mobility excitonic devices.

JW2A.35
Thermally-induced nonlinear spatial shaping of femtosecond pulses in nematic liquid crystals, Vittorio Maria Di Pietro[1,2], Aurelie Jullien[2], Umberto Bortolozzo[2], Nicolas Forget[1], Stefania Residori[2]; [1]*Fastlite, France;* [2]*INPHYNI, France.* Optically-induced thermal nonlinear effects in a thin nematic liquid-crystal result from light absorption by the ITO coating of an infrared femtosecond laser. Subsequent spatial shaping characterises the thermal gradient, up to the isotropic phase transition

JW2A.36
Orthogonal Four Wave Mixing in AlGaAs Nanowire Waveguides, Kyle A. Johnson[1], J. Stewart Aitchison[1]; [1]*Univ. of Toronto, Canada.* We propose a design and show simulation results for an AlGaAs waveguide device for performing four wave mixing where the pump mode has an orthogonal polarization to the signal and idler modes.

JW2A.37
Four-wave mixing microscopy of resonant silicon-on-insulator two-dimensional zero contrast gratings, Rabindra Biswas[1], Jayanta Deka[1], Keshav K. Jha[1], Vishnu Praveen[1], Lal Krishna A.S[1], Varun Raghunathan[1]; [1]*Indian Inst. of Science, India.* Four-wave mixing microscopy of resonant, silicon-on-insulator, two-dimensional zero-contrast grating is reported for large incident input wavelength separation of ~540 nm. Four-wave mixing signal on-grating is enhanced by 352x when compared to off-grating at resonance.

11:30–13:00 JW2A • Poster Session II and Lunch

JW2A.38

Polarization attractors generated from graphene polymer composite mode-locked erbium doped fiber laser, Chang Zhao[1], Qianqian Huang[1], Mohammed AlAraimi[3], Zinan Huang[1], Chengbo Mou[1], Aleksey Rozhin[2], Sergey Sergeyev[2]; *[1]Shanghai Univ., China; [2]Aston Inst. of Photonic Technologies, Aston Univ., UK; [3]Higher College of Technology, Oman.* We have experimentally investigated the polarization dynamics of an all-fiber passively mode-locked laser based on graphene using polarimeter for the first time. By carefully adjusting polarization controllers, two types of polarization attractors are obtained.

JW2A.39

Modulation Instability of Discrete Angular Momentum in Fiber Rings, Calum Maitland[1,2], Fabio Biancalana[1], Daniele Faccio[2]; *[1]Heriot-Watt Univ., UK; [2]School of Physics and Astronomy, Univ. of Glasgow, UK.* We present an analysis of modulation instability in a ring of coupled optical fibers. Plane waves are shown to be unstable to perturbations carrying discrete angular momenta, both for normal and anomalous group velocity dispersion.

JW2A.40

High-energy 9 µm LiGaS2-based Optical Parametric Chirped-Pulse Amplifier, Shizhen Qu[1], Houkun Liang[2], Xiao Zou[1], Kun Liu[1], Wenkai Li[1], Qijie Wang[1], Ying Zhang[2]; *[1]Nanyang Technological Univ., Singapore; [2]Singapore Inst. of Manufacturing Technology, Singapore.* We report the first LiGaS2-based mid-IR OPCPA, pumped by the 1-µm Yb:YAG laser at 10kHz. The idler pulse is centered at 9 µm, covering 7.5-10.2 µm wavelength range, with 13.8 µJ pulse energy.

JW2A.41

Paraxial Accelerating Beams along a Sharply Curved Path, Zekun Pi[1], Yi Hu[1], Zhigang Chen[1], Jingjun Xu[1]; *[1]Nankai Univ., China.* Sharply accelerating beams are commonly believed to exist only under non-paraxial conditions. Here we demonstrate that paraxial accelerating beams can be designed to travel along a steep parabolic path that conventional Airy beams cannot follow.

JW2A.42

Pseudo-Magnetic Monopole and Antimonopole in PT-Symmetric Coupled Waveguides, Rosie S. Hayward[1], Fabio Biancalana[1]; *[1]Heriot-Watt Univ., UK.* PT-symmetric coupled waveguides, for which the Berry curvature corresponds to a hyperbolic pseudo-magnetic monopole or antimonopole, are shown to have a purely imaginary Berry connection, which can induce gain and loss when it is non-periodic.

JW2A.43

Raman Induced Visible Stable Platicons and Breather Platicons in Microresonator, Shunyu Yao[1], Chengying Bao[2], Changxi Yang[1]; *[1]Tsinghua Univ., China; [2]California Inst. of Technology, USA.* We numerically demonstrate that stable platicons and coherent visible Kerr combs can be generated via Raman assisted four wave mixing in a AlN microresonator. Raman induced breather platicon dynamics is also observed in our simulations.

JW2A.44

Mid-infrared, Idler-resonant, Picosecond OP-GaAs OPO with Wide Tunability and Good Beam Quality, Qiang Fu[1], Lin Xu[1], Sijing Liang[1], Peter Shardlow[1], David Shepherd[1], Shaif-Ul Alam[1], David Richardson[1]; *[1]Optoelectronics Research Centre, UK.* We report an idler-resonant, watt-level, picosecond OP-GaAs OPO with a tuning range of 4394-6102 nm (idler) and 2997-3661 nm (signal), and diffraction-limited idler beam.

JW2A.45

Guiding and Routing of a Light Pulse via an Airy-like Accelerating Potential, Zhili Li[1], Ping Zhang[1], Xue Mu[1], Yi Hu[1], Zhigang Chen[1], Jingjun Xu[1]; *[1]Nankai Univ., China.* We demonstrate experimentally guiding pulse by pulse in an accelerating potential. Weak signals featured with single/double peaks can be guided to co-accelerate with a self-accelerating Airy pulse in an optical fiber.

JW2A.46

Bright Conical Diffraction at the Exceptional Point of PT and Anti-PT-Symmetric Photonic Lattices, Mojgan Dehghani[1], Hamidreza Ramezani[1]; *[1]Univ. of Texas Rio Grande Valley, USA.* We show that bright conical diffraction occurs at the exceptional points of 1D PT and anti-PT-symmetric photonic lattices.

JW2A.47

Characterization of Kerr Solitons in Microresonators with Parameter Optimization and Nonlinear Fourier Spectrum, Aiguo Sheng[1], Yilong Zhao[1], Guangqiang He[1]; *[1]Shanghai Jiao Tong Univ., China.* We investigate the influence of pump power and the number of driving modes on the soliton step and use nonlinear Fourier transform to characterize the Kerr soliton in the microresonator driven by pulses.

JW2A.48

Nucleation of Optical Vortices in the Wake of a Blockage in Free-Space Propagating Light, William G. Holtzmann[2], Samuel Alperin[2,1], Mark Siemens[2]; *[1]Dept. of Applied Mathematics and Theoretical Physics, Univ. of Cambridge, UK; [2]Dept. of Physics & Astronomy, Univ. of Denver, USA.* We report experiments observing optical vortex nucleation in light flowing past a blockage in free space. This nucleation in a fully linear system is analogous to fluid flow around different blockages.

JW2A.49

Phase Synchronization of Coupled Optical Oscillator, Mohammad-Ali Miri[1], Jiajie Ding[1]; *[1]Queens College of CUNY, USA.* The problem of creating phase synchronization between coupled optical oscillators of different individual frequencies is theoretically investigated. The synchronization coupling threshold is obtained for a dimmer as well as an array of coupled oscillators.

JW2A.50

Measurements of Resonant Kerr Self-focusing and Self-defocusing of Tunable, 4.3 µm Radiation in CO_2 Gas, Jeremy Pigeon[2], Dana Tovey[1], Sergei Tochitsky[1], Gerhardus Louwrens[1], Ilan Ben-Zvi[2], Chan Joshi[1], Dmitry Martyshkin[3], Vladimir Fedorov[3], Krishna Karki[3], Sergey Mirov[3]; *[1]Univ of California - Los Angeles, USA; [2]Physics and Astronomy, Stony Brook Univ., USA; [3]Physics, Univ. of Alabama at Birmingham, USA.* We report detailed measurements of resonant self-focusing and self-defocusing of a continuously tunable Fe:ZnSe laser operating within the 4P-branch of the CO_2 molecule. We determine the dispersion of this resonant nonlinearity near a rovibrational transition.

JW2A.51

Enhancement of Third Harmonic Generation in Organically Functionalized Microsphere Cavity, Jinhui Chen[1], Xiaoqin Shen[2], Qihuang Gong[1], Yun-Feng Xiao[1]; *[1]Peking Univ., China; [2]ShanghaiTech Univ., China.* We demonstrate efficient third harmonic generation (THG) in a high quality factor silica microsphere cavity, which is deposited with a layer of high optical nonlinearity molecules. The observed THG conversion efficiency is ~185%/W^2.

JW2A.52

Effect of linewidth dispersion in degenerate four wave mixing and Kerr-comb generation, Ali Eshaghian Dorche[1], Ali Eftekhar[1], Ali Adibi[1]; *[1]Georgia Inst. of Technology, USA.* We report the numerical study of linewidth dispersion effect on the degenerate four-wave mixing and the corresponding Kerr comb generation; for asymmetric linewidth difference around pumping wavelength, there is a threshold above which we see non-homogenous response corresponding to Turing roles.

JW2A.53

Sensitivity of Parameter Estimation Near the Exceptional Point of a Non-Hermitian System, Chong Chen[1], Liang Jin[2], Ren-Bao Liu[1]; *[1]Dept. of Physics, The Chinese Univ. of Hong Kong, Hong Kong; [2]Dept. of Physics, Nankai Univ., China.* The eigenvalue susceptibility divergence at the exceptional point (EP) stimulates the idea of high sensitivity metrology. Parameter estimation around the EPs is theoretically studied. We find that the EP bears no enhancement of the sensitivity.

JW2A.54

Large Purcell enhancement with nonreciprocal photon collection in a gap plasmon system, Fan Zhang[1], Lingxiao Shan[1], Xinjie Fang[1], Xueke Duan[1], Qihuang Gong[1], Ying Gu[1]; *[1]Peking Univ., China.* We achieve chiral light-emitter coupling with guided part Purcell enhancement of 1000$\ gamma_0$ and the directionality of 85% in a designed hybrid gap plasmon system, which provides an efficient way for nonreciprocal quantum photon sources.

JW2A.55

Laser Color Printing on Semicontinuous Silver Films, Sarah N. Chowdhury[1], Piotr Nyga[1,2], Zhaxylyk Kudyshev[1], Alexander Kildishev[1], Vladimir M. Shalaev[1], Alexandra Boltasseva[1]; *[1]Purdue Univ., USA; [2]Inst. of Optoelectronics, Military Univ. of Technology, Poland.* We demonstrate printing of colors from blue through green, yellow, orange to red using laser photomodification of semicontinuous silver films on mirror with dielectric spacer. The colors are controlled by laser fluence and exposure time.

JW2A.56

Tunable Localized Cosine-Gauss Beam generation through polarization control, Xuesi Zhao[1], Peng Zhao[1], Xue Feng[1], Yidong Huang[1]; *[1]Tsinghua Univeristy, China.* A nano-structure on metallic film is designed and fabricated to generate Localized Cosine-Gauss Beam while the propagating direction of generated surface plasmon polariton wave by modulating the polarization of illuminating lightbeam.

JW2A.57

Ultra-compact Polarization Emitter using a Silicon Nanoantenna, Zhongjin Lin[1], Wei Shi[1]; *[1]Université Laval, Canada.* We demonstrate an ultra-compact (3×4~$\rm \mu m$) silicon photonic nanoantenna that can generate an arbitrary polarization state through breaking the geometric symmetry. The emitted polarization state shows a weak wavelength dependence over the C-band.

JW2A.58

Using Dynamic Plasmonic Colors for Optical Cryptography, Maowen Song[2,1], Di Wang[1], Zhaxylyk Kudyshev[1], Alexandra Boltasseva[1], Honglin Yu[2], Vladimir M. Shalaev[1], Alexander Kildishev[1]; *[1]Purdue Univ., USA; [2]Chongqing Univ., China.* We experimentally demonstrate an all-aluminum metasurface that generates tunable plasmonic colors depending on the polarization states of the incident and reflected light. The metasurface produces high-resolution images and can be used to encrypt arbitrary information.

JW2A.59

Plasmonic System with In-Plane Magnetic Anisotropy for Plasmon Based Magnetic Switching, Mohammad Shahabuddin[1], Natalia Noginova[1]; *[1]Norfolk State Univ., USA.* Profile-modulated permalloy films are promising for magneto-optical applications. We show that such systems demonstrate plasmonic properties and have uniaxial in-plane anisotropy, which may allow sharp magnetization switching using SAM of light.

JW2A.60

Array of Symmetric Nanohole Dimers for STT-RAM Ultrathin Layer Sensing, Parinaz Sadri Moshkenani[1]; *[1]Univ. of California Irvine, USA.* Dimer nanohole array is designed to detect radiation effects in STT-RAM multilayer thin films, showing Fano resonance highly sensitive to dielectric layer changes. Normalized figure of merit is 13.5 times larger than single nanohole array.

11:30–13:00 JW2A • Poster Session II and Lunch

JW2A.61
Microcavity-Powered Local Field Enhancement at Plasmonic Nanoantennas, Jui-Nung Liu[1,2], Qinglan Huang[1,2], Keng-Ku Liu[3], Srikanth Singamaneni[3], Brian T. Cunningham[1,2]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA;* [2]*Micro and Nanotechnology Lab, Univ. of Illinois at Urbana-Champaign, USA;* [3]*Dept. of Mechanical Engineering and Materials Science, Washington Univ. in St. Louis, USA.* We demonstrate cooperative plasmonic–photonic hybridization with an integration of gold nanorods (as nanoantennas) and an on-resonance dielectric photonic crystal slab (as a microcavity). The cavity-enhanced impedance-matched light-matter interface offers great local field amplifications.

JW2A.62
A Novel Platform for the Detection and Analysis of Plasmonic Nanostructures Based on Nanomechanical Resonator, Miao-Hsuan Chien[1], Mostafa Shawrav[1], Heinz Wanzenboeck[2], Silvan Schmid[1]; [1]*Inst. of sensor and actuator system, TU Wien, Austria;* [2]*Inst. of solid state electronics, TU Wien, Austria.* A novel platform for the detection of plasmonic resonance is demonstrated with silicon nitride nanomechanical resonator. Absorption cross section could be obtained directly from the detuning of mechanical frequency. This technique provides an alternative for the optimization of plasmonic designs.

JW2A.63
Strontium Niobate for Near Infrared Plasmonics, Aveek Dutta[1], Dongyang Wan[2], Bixing Yan[2], Vladimir M. Shalaev[1], Thirumalai Venkatesan[2], Alexandra Boltasseva[1]; [1]*Purdue Univ., USA;* [2]*National Univ. of Singapore, Singapore.* We study Strontium Niobate (SNO) as an alternate material for plasmonics in the near infrared wavelength range. We demonstrate, experimentally and through numerical simulations, hybrid plasmonic-photonic resonances in a SiO_2-Si nanodisk stack on SNO near technologically important telecom window.

JW2A.64
Near-Ultraviolet Dielectric Metasurfaces for Surface-Enhanced Circular Dichroism Spectroscopy and Handedness-Preserved Reflection, Kan Yao[1], Yuebing Zheng[1]; [1]*The Univ. of Texas at Austin, USA.* We report a design of achiral dielectric metasurfaces that can enhance the circular dichroism of chiral molecules for over 50 times and preserve the spin states of light upon reflection in the near-ultraviolet region.

JW2A.65
A control of localized surface phonon polariton resonance using metal/dielectric multilayer boundary, Satyanarayana R. Kachiraju[1]; [1]*UTRGV, USA.* We fabricated subwavelength grating of a metal/dielectric multilayer on silicon carbide. We experimentally demonstrated a control of localized surface phonon polariton resonance showing near perfect infrared absorption at the optical phonon band of silicon carbide.

JW2A.66
A Comparison of Metal Adhesion Layers for Au Films in Thermo-Plasmonic Applications, Willian Abbott[1,2], Christopher P. Murray[1,2], Sorcha NiLochlainn[1,2], Frank Bello[1,2], Chuan Zhong[1,2], Christopher Smith[1,2], Amanda Petford-Long[3], John Donegan[1,2], McCloskey David[1,2]; [1]*School of Physics , Ireland;* [2]*Trinity College, Ireland;* [3]*Material Science Division, Argonne National Lab, USA.* The dewetting resistance of Au 50 nm films fabricated atop Ti/Ta/W/Cr/Al adhesion layers (0.5-5 nm) was investigated. Results show sub-nanometer Ta has superior stability under thermal stress, while W & Ti show best plasmonic response.

JW2A.67
Generation of 104 nJ, 100 kHz Pulses directly from all-Normal Dispersion all-PM Yb-fiber Laser with a Nonlinear Amplifying Loop Mirror, Yuhang Shi[1], Zhaochen Cheng[1], Chang Hong[1], ZhiGang Peng[1], Pu Wang[1]; [1]*Beijing Univ. of Technology, China.* We demonstrate a mode-locked all-PM Yb-doped fiber laser using nonlinear amplifying loop mirror, delivering 300 ps pulses with energy of 104 nJ at repetition rate of 100 kHz, which can be compressed to 1.053 ps.

JW2A.68
Generation and Frequency-conversion of Optical Vortex Arrays with Controlled Intensity Distribution, SS Harshith Bachimanchi[1], Goutam Samanta[2]; [1]*IISER Pune, India;* [2]*Atomic, Molecular and Optical Physics, Physical Research Lab(PRL), India.* We report on the generation of high power ultrafast optical vortex arrays of controlled intensity distribution. Using microlens array we have generated vortex arrays at 1064 nm and frequency-doubled into vortex arrays at new wavelength.

JW2A.69
Grating-Based Mid-Infrared Long-Pass Filter for High-Power Applications, Wolfgang Schweinberger[2,3], Daniel Gerz[1,2], Thomas P. Butler[1], Thomas Siefke[4,6], Martin Heusinger[4], Tatiana Amotchkina[2], Vladimir Pervak[2], Uwe Zeitner[4,5], Ioachim Pupeza[1,2]; [1]*Max Planck Insititute of Quantum Optics, Germany;* [2]*Dept. of Physics, Ludwig Maximillian Univ. Munich, Germany;* [3]*Dept. of Physics and Astronomy, King Saud Univ., Saudi Arabia;* [4]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany;* [5]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany;* [6]*Physikalisch-Technische Bundestalt, Germany.* We present a gold-coated silicon grating which provides efficient spatial separation of a broadband mid-infrared (MIR) beam from a collinear, 30W beam of broadband near-infrared (NIR) pulses in a power-scalable and chromatic dispersion-free manner.

JW2A.70
Withdrawn

JW2A.71
Single-shot Subnoise Signal Recovery by Coherent Spectral Energy Redistribution, Benjamin G. Crockett[1], Luis Romero Cortes[1], Saikrishna Reddy K[1], Jose Azana[1]; [1]*INRS, Canada.* We demonstrate single-shot recovery of subnoise signals, completely buried under random in-band noise, through combinations of phase manipulations derived from Talbot effect theory, allowing for reconstruction of signals with a time-bandwidth-product of up to 24.

JW2A.72
Demonstration of Space-Time Wave Packets That Travel in Optical Materials at the Speed of Light in Vacuum, Basanta Bhaduri[1], Murat Yessenov[1], Ayman F. Abouraddy[1]; [1]*Univ. of Central Florida, CREOL, USA.* We synthesize optical wave packets that travel in transparent non-dispersive materials (liquids, glasses, and sapphire) at the speed of light in vacuum, independently of the refractive index, by introducing carefully designed spatio-temporal field spectral correlations.

JW2A.73
High-efficiency nonlinear compression using a gas-filled multipass cell, Florent Guichard[1], Loïc Lavenu[1], Michele Natile[1], Xavier Delen[2], Yoann Zaouter[1], Marc Hanna[2], Eric Mottay[1], Patrick Georges[2]; [1]*Amplitude Laser Group, France;* [2]*Laboratoire Charles Fabry, France.* We demonstrate nonlinear temporal compression of a Yb-doped fiber amplifier in a multipass-cell filled with argon. The 160µJ 275fs pulses are compressed down to 135µJ and 33fs, corresponding to a transmission of 85%.

JW2A.74
Phase noise performance of filtered optical frequency comb, Lawrence Trask[1], Ricardo Bustos-Ramirez[1], Michael Plascak[1], Peter Delfyett[1]; [1]*Univ. of Central Florida, USA.* We determined the key parameters in low phase noise performance in filtered optical frequency combs. Laser frequency fluctuation and filter passband width as well as spectral phase play a role in obtaining low timing jitter.

JW2A.75
Generation of ultra-stable 50-fs pulses directly from an Er-doped fiber oscillator, Jiaqi Zhou[1], Weiwei Pan[1], Yan Feng[1]; [1]*Shanghai Inst. of Optics & Fine Mech., China.* We report on an Er-doped fiber laser which can generate few-cycle pulses with excellent long-term stability. The all-polarization-maintaining fiber oscillator can produce 50-fs pulses with 13.6-mW average output power at 85.3-MHz repetition rate.

JW2A.76
100% Reliable Frequency-Resolved Optical Gating Pulse-Retrieval Algorithmic Approach, Rana Jafari[1], Travis N. Jones[1], Rick Trebino[1]; [1]*Georgia Inst. of Technology, USA.* We introduce a FROG algorithmic approach that always converges and is faster. It involves retrieving the correct spectrum directly from the trace and implementing a multi-grid scheme with multiple initial guesses.

JW2A.77
Optofluidic SERS Sensing from Photonic Crystal-Plasmonic Mesocapsules, Kundan Sivashanmugan[1], Kenneth Squire[1], Yong Zhao[1,2], Ailing Tan[2], Joseph Kraai[1], Gregory Rorrer[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*Yanshan Univ., China.* We synthesized hybrid photonic crystal-plasmonic mesocapsules using diatom biosilica with in-situ growth silver nanoparticles. The mesocapsules achieved near single-molecule sensitivity for optofluidic SERS sensing with five orders of magnitude higher than colloidal nanoparticles.

JW2A.78
Ring Resonator Based Ultrasound Detection in a Zero-Change Advanced CMOS-SOI Process, Panagiotis Zarkos[1], Olivia Hsu[1], Vladimir Stojanovic[1]; [1]*UC Berkeley, USA.* Optical ultrasound detection using microring resonators (MRRs) in a zero-change 45nm CMOS-SOI electronic-photonic platform with high intrinsic sensitivity of 39.6 fm/kPa and frequency response of 6MHz is reported.

JW2A.79
Ultrahigh-speed spatial pattern projection using a nonlinear optical time lens for fast single-pixel imaging, Jasper R. Stroud[1], Mark Foster[1]; [1]*Johns Hopkins Univ., USA.* We present a method for projecting programmable spatial patterns at a rate of 289 Gpixels/s using a nonlinear optical time lens. Using this projector, we demonstrate high-speed single-pixel imaging using compressed sensing.

JW2A.80
Calibration-Free Time-Stretch Optical Coherence Tomography Based on Higher-Order Dispersion Compensation, Lei Zhang[1], Liao Chen[1], Zihui Lei[1], Yuhua Duan[1], Chi Zhang[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, Huazhong Univ. of Science and Technology, China.* We demonstrate a calibration-free time-stretch optical coherence tomography, which substitutes the calibration by dispersion compensation. It minimizes the data processing time by 20 times, which is essential for A-scan rate as high as 20 MHz.

JW2A.81
Electronic-Photonic Platform for Label-Free Biophotonic Sensing in Advanced Zero-Change CMOS-SOI Process, Christos G. Adamopoulos[1], Asmaysinh Gharia[2], Ali Niknejad[1], Mekhail Anwar[2], Vladimir Stojanovic[1]; [1]*Dept. of Electrical Engineering and Computer Science, Univ. of California, Berkeley, USA;* [2]*Dept. of Radiation Oncology, Univ. of California, San Francisco, USA.* We propose a monolithically integrated platform in a CMOS 45RFSOI process for biophotonic sensing. This platform opens the pathway to the first Lab-on-Chip system with nanophotonic sensing and advanced electronics on a single die.

JW2A.82
Microfluidic Mid-Infrared Spectroscopy via Microresonator-Based Dual-Comb Source, Mengjie Yu[1,2], Yoshitomo Okawachi[1], Austin Griffith[2], Michal Lipson[1], Alexander Gaeta[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA.* We combine microfluidic technology with microresonator-based mid-infrared dual-comb spectroscopy. We measure flow dynamics of acetone with a spectral acquisition rate of 200-kHz over 90 cm^{-1}span and <150 fL sample volume over a 100-ms period.

JW2A.83
Beam Shaping with Axicons for Low Loss Microscopy Optics, Natsuha Ochiai[1], Jingwen Shou[1], Yasuyuki Ozeki[1]; [1]*The Univ. of Tokyo, Japan.* We propose a beam shaping method using two axicons for reducing optical loss in broadband microscopy optics. We demonstrate high transmittance and high spatial resolution without sacrificing signal intensity in stimulated Raman scattering microscopy.

11:30–13:00 JW2A • Poster Session II and Lunch

JW2A.84
Withdrawn

JW2A.85
Bound States in a Harmonic Graphene-Mode-Locked Fiber Laser, Bo Fu[1,2], Jin Li[3], Zhang Cao[2,1], Daniel Popa[3]; [1]*Beijing Advanced Innovation Center for Big Data-Based Precision Medicine, Beihang Univ., China;* [2]*School of Instrumentation and Optoelectronic Engineering, Beihang Univ., China;* [3]*Electrical Engineering, Univ. of Cambridge, UK.* A solution-processed graphene-film deposited on a fiber-based connector is used for stable bound states of solitons in a harmonic mode-locked all-fiber laser at harmonics up to the 26th.

JW2A.86
104 fs mode-locked fiber laser with a MXene-based saturable absorber, Qing Wu[1], Meng Zhang[1], Xinxin Jin[1], Si Chen[2], Quanyu Jiang[1], Xiantao Jiang[2], Zheng Zheng[1], Han Zhang[2]; [1]*Beihang Univ., China;* [2]*Shenzhen Univ., China.* We report an all-fiber erbium-doped laser mode-locked by a microfiber-based MXene saturable absorber, generating 104-fs pulses with 42.5-nm spectral width. Our work adds MXene to the growing catalogue of nanomaterials for future nonlinear photonics.

JW2A.87
Spatiotemporal Dynamics of Dual-Soliton States in a Multimode Fiber Laser, Yihang Ding[1], Xiaosheng Xiao[1], Changxi Yang[1]; [1]*Tsinghua Univ., China.* We report on experimental observation of three types of dual-soliton states in a spatiotemporal mode-locked multimode fiber laser. The spatiotemporal dynamics are found different for these states.

JW2A.88
1.94 GHz Passively Harmonic Mode-locked All-fiber Laser Using Polarization-maintaining Helical Long-period Grating, Qianqian Huang[1], Chen Jiang[1], Chuanhang Zou[1], Zinan Huang[1], Chengbo Mou[1], Yunqi Liu[1]; [1]*Shanghai Univ., China.* We have demonstrated an all-fiber passively harmonic mode-locked laser by using helical long-period grating inscribed in polarization-maintaining fiber for the first time. 1.94 GHz pulses at 63rd harmonic with 49.5dB super-mode suppression ratio are obtained.

JW2A.89
High Absorption Low NA Step Index Large-Mode-Area Fiber for High Power Ultrafast Lasers, Raghuraman Sidharthan[1], Kang Jie Lim[2], Serene Huiting Lim[2], Huizi Li[1], Yanyan Zhou[1], Junhua Ji[1], Yue Men Seng[1], Song Liang Chua[2], Seongwoo Yoo[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*DSO National Labs, Singapore.* We report fabrication of >20dB/m cladding absorption step-index LMA fiber with low core NA(<0.07) suitable for ultra-fast fiber lasers. Above 58W output power with a slope efficiency of ~80% was demonstrated in only 0.5m fiber.

JW2A.90
Self-parametric amplification in ultrafast fibre lasers, Heping Zeng[1], Junsong Peng[1]; [1]*East China Normal Univ., China.* Self-parametric amplification is employed as a novel gain mechanism in ultrafast fibre lasers, which transfers energy from the spectral tails to the center within the laser field. The laser outputs three pulses with different spectra.

JW2A.91
Highly Sensitive Liquid Level Sensor Based on Microstructured Optical Fiber, Wei Zhang[1], Fan Ai[1], Zhikun Xing[1], Wei Zhou[1], Zhijun Yan[1], Deming Liu[1], Qizhen Sun[1]; [1]*Huazhong Univ of Science and Technology, China.* A highly sensitive liquid level sensor based on microstructured optical fiber is experimentally demonstrated. The proposed sensor can achieve the fully distributed liquid level monitoring with the resolution of 74μm with large detecting range.

JW2A.92
All-Polarization Maintaining, Bi-directional, Er-doped, Dual-comb Fiber Laser with Single Wall Carbon Nanotube, Shuto Saito[1], Masahito Yamanaka[1], Youichi Sakakibara[2], Emiko Omoda[2], Hiromichi Kataura[2], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan;* [2]*AIST, Japan.* All polarization maintaining, bi-directional, Er-doped, dual-comb fiber laser using carbon nanotube polyimide film was demonstrated. Optical spectra of output pulses were almost the same, and stable soliton mode-locking operation was achieved for long term.

JW2A.93
Demonstration of the Coherent Mid-IR Supercontinuum Generation in Tapered Tellurite Fiber, Than Singh Saini[1], Hoa P. Nguyen[1], Luo Xing[1], Tong H. Tuan[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Toyota Technological Inst., Japan.* Coherent supercontinuum spectrum spanning 1.28 - 3.31 μm at -40 dB intensity level is obtained using an all-normal dispersion tapered tellurite fiber pumped by 200 fs laser pulse of peak power of 19.8 kW at 2.0 μm.

JW2A.94
The Impact of Saturable Absorber Recovery Time in Hybrid Mode-Locked Fiber Laser Design, Lei Jin[1], Chao Zhang[1], Neisei Hayashi[1], Sze Y. Set[1], Shinji Yamashita[1]; [1]*Univ. of Tokyo, Japan.* Saturable absorber recovery time plays an important role in a hybrid mode-locked fiber laser. Our investigation reveals that a shorter recovery time is preferred for the hybrid scheme combined with nonlinear polarization rotation.

JW2A.95
Single-aperture passive coherent beam combining of fiber lasers based on diffractive optical element, Gang Bai[1,2], Hui Shen[1], Meizhong Liu[1,2], Kai Liu[1], Haibo Zhang[1], Xiaxia Niu[1,2], Yifeng Yang[1], Bing He[1,3], Jun Zhou[1,3]; [1]*Shanghai Key Lab of All Solid-State Laser and Applied Techniques, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Univ. of Chinese Academy of Sciences, China;* [3]*Nanjing Inst. of Advanced Laser Technology, China.* We demonstrate a single-aperture coherent beam combination with eight fiber laser beamlets using a one-dimention diffractive optical element in an all-optical feedback loop. The maximum output power is 1.5 W with near diffraction-limited beam quality.

JW2A.96
Light propagation properties of a novel tellurite hollow-core fiber with single hexagonal air-hole layer, Hoang Tuan Tong[1], Nobuhiko Nishiharaguchi[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Toyota Technological Inst., Japan.* We experimentally demonstrated the fabrication of a new tellurite hollow core photonic crystal fiber with a single hexagonal air-hole layer and studied its light propagation and transmission properties from 0.4 to 2.4 μm.

JW2A.97
High Repetition Rate Visible Frequency Comb Generation From Electro-Optic Modulation in the 1550 nm Region, Ken Kashiwagi[1,2], Sho Okubo[1,2], Hajime Inaba[1,2]; [1]*National Metrology Inst. of Japan, AIST, Japan;* [2]*JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan.* We generated a 10-GHz spacing visible frequency comb from an EOM-based comb in the 1550 nm region. A waveguide-type periodically-polled lithium niobate produced third and fourth harmonics comb, which ranging in the visible region.

JW2A.98
Dispersion Managed, High Power Tm-doped Ultrashort Pulse Fiber Laser at 1.9 um Using Single Wall Carbon Nanotube Polyimide Film, Kenta Watanabe[1], Y. Zhou[2], Takeshi Saito[2], Youichi Sakakibara[2], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan;* [2]*AIST, Japan.* High power Tm-doped ultrashort pulse fiber laser operated at 1.9 um was demonstrated using single wall carbon nanotube dispersed in polyimide film. A 1.7 nJ, 36 mW high power dissipative soliton pulse was obtained.

JW2A.99
1-MHz, Energetic Ultrafast Source Tunable Between 940-1250 nm for Multi-photon Microscopy, Yang Yu[1,2], Shaobo Fang[2,3], Hao Teng[2,3], Jiangfeng Zhu[1], Junli Wang[1], Guoqing Chang[2,3], Zhiyi Wei[2,3]; [1]*Xidian Univ., China;* [2]*Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China;* [3]*School of Physical Science, Univ. of Chinese Academy of Sciences, China.* We demonstrate a 1-MHz ultrafast fiber-optic source that produces ~100-fs pulses tunable from 940 nm to 1250 nm with up to 33-nJ pulse energy. Such a source is ideal for driving multi-photon microscopy.

JW2A.100
Inclinometer Based on Optical Microfiber Probes, Junjie Wang[1], Shijie Tan[1], Wei Zhang[1], Yanpeng Li[1], Qizhen Sun[1], Deming Liu[1]; [1]*Huazhong Univ of Science and Technology, China.* An inclinometer based on optical microfiber probes is proposed and experimentally demonstrated, which is capable of measuring the tilt angle and direction simultaneously with a resolution lower than 0.0004° within ± 5°.

JW2A.101
High Resolution π-Phase-Shifted Fiber Bragg Grating Demodulator using Frequency Swept DFB Laser, Jiageng Chen[1], Qingwen Liu[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China.* A π-phase-shifted fiber Bragg grating demodulator has been proposed based on feed-forward linewidth suppression of frequency swept DFB laser. Wavelength resolution of 3.2 fm in 0.4 nm scan range is achieved in the demonstration.

JW2A.102
Discrete Fourier domain mode locked laser with a microring resonator, Dongmei Huang[1], Feng Li[2], Huiwen Luo[3], Chao Shang[1], Nan Guo[1], Liang Wang[3], Sai Chu[4], Xinhuan Feng[5], P. K. A. Wai[1]; [1]*The Hong Kong Polytechnic Univ., Hong Kong;* [2]*The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China;* [3]*Univ. of Science and Technology of China, China;* [4]*City Univ. of Hong Kong, Hong Kong;* [5]*Jinan Univ., China.* We propose and experimentally demonstrate a discrete Fourier domain mode locked (FDML) laser with more than 100 nm bandwidth by utilizing a microring resonator as frequency comb filter.

JW2A.103
Parabolic Pulse Generation in Totally Passive Tapered Multimode Fibers, Helena E. Lopez Aviles[2], Michael Buttolph[1], Frank W. Wise[1], Rodrigo Amezcua Correa[2], Demetrios N. Christodoulides[2]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA;* [2]*CREOL, College of Optics and Photonics, Univ. of Central Florida, USA.* We propose a new method to generate self-similar parabolic pulses in exponentially tapered multimode fibers. In such broadband amplification-free settings the input pulse can quickly acquire a parabolic profile with a high quality linear chirp.

JW2A.104
Tri-comb and quad-comb generation from a multi-dimensional-multiplexed fiber laser, Ting Li[1], Xin Zhao[1], Jie Chen[1], Qian Li[1], Zheng Zheng[1,2]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*Beijing Advanced Innovation Center for Big Date-based Precision Medicine, China.* By tapping into multiple wave-guiding dimensions in optical fiber, it is demonstrated that up to four wavelength/polarization multiplexed, asynchronous ultrashort pulse sequences can be generated with good stability from an all-fiber, ring-cavity, mode-locked fiber laser.

JW2A.105
Surface-enhanced Raman scattering sensor based on soft polymer optical fibers, Jingjing Guo[1], Yuqing Luo[1], Changxi Yang[1], Lingjie Kong[1]; [1]*Tsinghua Univ., China.* We present a novel SERS probes based on soft polymer optical fibers with physio-mechanical properties suitable for implantation, and demonstrate their potential applications for *in-situ* detection of bioanalytes.

11:30–13:00 JW2A • Poster Session II and Lunch

JW2A.106
Fast M^2 estimation for fiber beams through deep learning, Liangjin Huang[1], Pu Zhou[1], Yi An[1], Jinyong Leng[1], Lijia Yang[1], Jun Li[1]; [1]*National Univ of Defense Technology, China.* We have firstly utilized deep learning (DL) in M^2 estimation for fiber beams. The simulations have proved our scheme is accurate and M^2 can be determined within ~ 3 ms using a trained DL network.

JW2A.107
Fabrication and Characterization of Birefringent Bismuth and Erbium Co-Doped Photonic Crystal Fiber for Broadband Polarized Near Infrared Emission, Yushi Chu[1,2], Yuan Tian[2], Desheng Fan[2], Gui Xiao[2], Shuen Wei[2], Bowen Zhang[2], Xinghu Fu[2], Zhanyu Ma[1], Quan Chai[1], Jing Ren[1], Jianzhong Zhang[1], Yanhua Luo[2], Gang-Ding Peng[2]; [1]*School of Science, Harbin Engineering Univ., China;* [2]*School of Electrical Engineering & Telecommunications, Univ. of New South Wales, Australia.* Birefringent bismuth and erbium co-doped photonic crystal fiber (B-BEPCF) by preform stacking technology has been fabricated and characterized. Results demonstrate broadband and elliptically polarized near infrared (NIR) emission under 532 or 830 nm pumping, respectively.

JW2A.108
Suspended-core fiber based Sagnac interferometer device and sensing applications, Yu Zheng[1,2], Perry Ping Shum[1,2], Yiyang Luo[1,2], Yanan Zhang[2,3], Zhifang Wu[4], Jean-Louis Auguste[5], Georges Humbert[5]; [1]*COFT, School of EEE, Nanyang Technological Univ., Singapore;* [2]*CINTRA, CNRS/NTU/Thales Research Alliance, Singapore;* [3]*College of Information Science and Engineering, Northeastern Univ., China;* [4]*College of Information Science and Engineering, Huaqiao Univ., China;* [5]*XLIM Research Inst., France.* Optical fiber based interferometers have been used for numerous sensing applications. Here, we develop an all-fiber Sagnac interferometer device based on suspended-core fiber, which can be excellent candidates for physical or biochemical sensors.

JW2A.109
Experimental Demonstration of Highly Coherent Near to Mid-Infrared Supercontinuum Generation with All-solid Hybrid Microstructured Tellurite Fiber, Hoa P. Nguyen[1], Tuan H. Tong[1], Luo Xing[1], Thai Singh Saini[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Toyota Technological Inst., Japan.* A highly coherent supercontinuum spanning from 1.4 to 3 µm was generated in an all-solid hybrid microstructured tellurite fiber pumped by a laser operating at 2 µm.

JW2A.110
Demonstration of dichroic atomic vapor laser lock in micro fabricated vapor cell using light induced atomic desorption, Eliran Talker[1], P. Arora[1], Roy Zektzer[1], Yefim Barash[1], Noa Mazurski[1], Yoel Sebbag[1], Uriel Levy[1]; [1]*The Hebrew Univ. of Jerusalem, Israel.* We demonstrate Dichroic Atomic Vapor Laser Lock (DAVLL) using light induced atomic desorption in micro fabricated vapor cell. We have stabilized a 780 nm laser with a precision better than 400 kHz without heating.

JW2A.111
A Compact Physics Package of a Chip-scale Atomic Clock with a Built-in Magnetic Shield, Hyun-Gue Hong[2], Jongcheol Park[1], Tae Hyun Kim[1], Hee Yeoun Kim[1], Sang-Eon Park[2], Sang-Bum Lee[2], Myoung-Sun Heo[2], Taeg Yong Kwon[2]; [1]*National NanoFab Center, South Korea (the Republic of);* [2]*South Korea Research Inst. of Standards and Science, South Korea (the Republic of).* We demonstrate a physics package for chip-scale atomic clocks in which the supporting frame itself serves as a primitive magnetic shield (~20x attenuation). It measures 4.9x4.9x4.5 mm^3 with its frequency instability ~10^{-10} at 1 s.

JW2A.112
Optimizing the dipole trap for loading laser-cooled atoms into hollow-core fibers, Taehyun Yoon[1], Paul Anderson[1], Sheng-Xiang Lin[1], Bryan Duong[1], Michal Bajcsy[1]; [1]*Univ. of Waterloo, Canada.* We study the effects of dipole trap wavelength and power on the number of laser-cooled atoms loaded into a hollow-core optical fiber to optimize the trade-offs between the observed loss mechanisms.

JW2A.113
Coherent atomic microwave sensor, Vladislav Gerginov[2,1], Fabio da Silva[1], Craig Nelson[1], Archita Hati[1]; [1]*Time and Frequency, NIST, USA;* [2]*Physics, Univ. of Colorado Boulder, USA.* We developed a room-temperature microwave signal atomic sensor that converts coherently a low-power microwave signal to polarization modulation of a probe light field. The sensitivity rivals that of microwave field probes based on Rydberg atoms.

JW2A.114
Efficient hyperfine optical pumping of Rb atoms in Miniaturized vapor cells, Eliran Talker[1], P. Arora[1], Mark Dikopoltsev[1,2], Uriel Levy[1]; [1]*Dept. of Applied Physics, The Hebrew Univ. Jerusalem, Israel, Israel;* [2]*RAFAEL, Science Center, Rafael Ltd, Haifa (Israel), Israel.* We demonstrate the positive role of buffer gas in achieving highly efficient hyperfine-structure based optical pumping of Rubidium atoms in miniaturized vapor cells. At a pressure of 40 Torr, pumping efficiency of 85% is achieved.

JW2A.115
Sodium Magnetometry, Yan Feng[1], Tingwei Fan[1], Tianhua Zhou[1]; [1]*Shanghai Inst of Optics & Fine Mechanics, China.* Magnetic resonance of sodium fluorescence is investigated and a magnetometer based on sodium vapor is demonstrated. The study is motivated by remote magnetometry with mesospheric sodium. Results of on-sky tests are reviewed.

JW2A.116
Multiparameter Quantum Tracking of Optical Activity, Valeria Cimini[1], Ludovica Ruggiero[1], Ilaria Gianani[1], Marco Sbroscia[1], Tecla Gasperi[1], Emanuele Roccia[1], Luca Mancino[1], Daniela Tofani[1], Fabio Bruni[1], Maria Antonietta Ricci[1], Marco Barbieri[1]; [1]*Università degli studi Roma Tre, Italy.* Quantum sensors can be used to monitor the dynamic of chemical processes. Here we implement a multiparameter protocol, on two different chemical reactions, robust against time-varying noise.

JW2A.117
Truncated nonlinear interferometric cantilever beam-displacement: accessible quantum sensing, Benjamin Lawrie[1], Jacob Beckey[1], Raphael C. Pooser[1]; [1]*Oak Ridge National Lab, USA.* We show that relative beam displacement measurements with two-mode squeezed light sources are identical to truncated SU(1,1) interferometers, enabling a new quantum-enhanced atomic force microscopy suitable for broadband characterization of high-speed dynamics in materials.

JW2A.118
Planar Alignment of Graphene Sheets by a Rotating Magnetic Field for Polarizer and Display Applications, Feng Lin[2,3], Guang Yang[2], Chao Niu[1], Yanan Wang[2], Zhuan Zhu[2], Haokun Luo[4], Chong Dai[2], Junyi Zhao[4], Yandi Hu[2], Xufeng Zhou[5], Zhaoping Liu[5], Zhiming Wang[3], Jonathan Hu[1], Jiming Bao[2,3]; [1]*Baylor Univ., USA;* [2]*Univ. of Houston, USA;* [3]*Univ. of Electronic Science and Technology of China, China;* [4]*Huazhong Univ. of Science and Technology, China;* [5]*Chinese Academy of Sciences, China.* Rotating magnetic field produced by commercial NdFeB magnet is used for planar alignment of graphene sheets in suspension. We demonstrate high optical anisotropy of aligned graphene sheets for polarizer and display applications.

JW2A.119
Colloidal Self-Assembled Approach Towards Hybrid Waveguide-Plasmon Resonances, Swagato Sarkar[1], Tobias A. König[2], Joby Joseph[1]; [1]*Indian Inst. of Technology, Delhi, India;* [2]*Physical Chemistry and Polymer Physics, 1Leibniz-Institut für Polymerforschung Dresden e.V. (IPF), Germany.* We demonstrate fabrication of a hybrid opto-plasmonic structure through combination of rapid top-down laser-interference lithography and bottom-up colloidal self-assembly methods. The supported hybridized resonances are compared in depth experimentally along with simulation models.

JW2A.120
Burst-Mode Ultraviolet Laser Pulses at Megawatt Peak Power in a Doubly-Resonant Enhancement Cavity, Abdurahim Rakhman[1], Yun Liu[1]; [1]*Oak Ridge National Lab, USA.* We demonstrate power enhancement of burst-mode UV (355 nm) laser with 50 ps pulse width and 402.5 MHz repetition rate. Peak intracavity power of >1.5 MW has been achieved for bunches with 10 µs at 10 Hz rate in a doubly-resonant optical cavity under high vacuum.

JW2A.121
Photonic Crystal Behavior of Nitzschia Filiformis Phytoplankton for Chlorophyll A Photosynthesis, Yannick D'Mello[1], Santiago Bernal[1], James Skoric[1], Dan Petrescu[1], Mark Andrews[1], David V. Plant[1]; [1]*McGill Univ., Canada.* Photonic band structure simulations of Nitschia Filiformis diatom frustules revealed resonances at wavelengths corresponding to both peaks in the chlorophyll A absorption spectrum. The behavior at 658 nm wavelength was investigated using near-field optical microscopy.

JW2A.122
Optimization of Chalcogenide Negative Curvature Fibers for CO_2 Laser Transmission, Chengli Wei[2], Curtis R. Menyuk[3], Jonathan Hu[1]; [1]*Electrical and Computer Engineering, Baylor Univ., USA;* [2]*Computer Science, Engineering and Physics, Univ. of Mary Hardin-Baylor, USA;* [3]*Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA.* We study the geometry of chalcogenide negative curvature fibers with different numbers of tubes and different core diameters. We optimize the design of chalcogenide negative curvature fibers for CO_2 laser transmission.

Executive Ballroom 210A

Joint

13:00–15:00
JW3A • Sym on Coupling Artificial Atoms to Nano- & Opto-mechanical Systems I
Presider: To Be Announced

JW3A.1 • 13:00 Invited
Toward Novel Coherence Protection and Sensing Techniques: Closed Counter Interaction Using a Single Spin. Mark Kasperczyk[1], Johannes Kolbl[1], Arne Barfuss[1], Patrick Maletinsky[1]; *Univ. of Basel, Switzerland.* By studying Nitrogen Vacancy (NV) centers embedded in diamond cantilevers, we show that the coupling between the cantilever and the NV leads to novel coherent population dynamics when combined with two microwave driving fields.

JW3A.2 • 13:30 Invited
Spin and Orbital Resonance Driven by a Mechanical Resonator, Gregory Fuchs[1]; [1]*Applied and Engineering Physics, Cornell Univ., USA.* I will describe our experiments to drive spin and orbital resonance of single diamond nitrogen-vacancy (NV) centers using the gigahertz-frequency strain oscillations produced within a diamond acoustic resonator.

JW3A.3 • 14:00
Diamond Phononic Crystal Spin-Mechanical Resonators with Spectrally-Stable Nitrogen Vacancy Centers, Ignas Lekavicius[1], Thein Oo[1], Hailin Wang[1]; [1]*Univ. of Oregon, USA.* We report the design and fabrication of GHz diamond spin-mechanical resonators embedded in a two-dimensional phononic crystal lattice. Spectrally-stable nitrogen vacancy centers are observed after a soft-etching surface treatment.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

13:00–15:00
FW3B • Chip-scale Nonlinear Optics
Presider: To Be Announced

FW3B.1 • 13:00
Second-Harmonic Diffraction from Periodically Structured MoS_2 Monolayer, Franz J. Löchner[1], Rajeshkumar Mupparapu[1], Michael Steinert[1], Antony George[2], Andrey Turchanin[2], Thomas Pertsch[1,3], Isabelle Staude[1], Frank Setzpfandt[1]; [1]*Inst. of Applied Physics, Friedrich Schiller Univ. Jena, Germany;* [2]*Inst. of Physical Chemistry, Friedrich Schiller Univ. Jena, Germany;* [3]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We investigate second-harmonic generation from one-dimensional gratings in MoS_2 monolayer flakes structured by focused ion beam milling, and observe diffraction orders due to nonlinear diffraction from the periodic structure.

FW3B.2 • 13:15
Non-reciprocal delay based on photon-phonon interactions on a chip, Moritz Merklein[1], Birgit Stiller[1], Khu Vu[2], Pan Ma[2], Stephen Madden[2], Benjamin J. Eggleton[1]; [1]*The Univ. of Sydney, Australia;* [2]*Australian National Univ., Australia.* We demonstrate a non-reciprocal delay scheme based on stimulated Brillouin scattering in a planar highly nonlinear waveguide. The bandwidth of this scheme approaches a GHz, has wide frequency tunability and scales linearly with data power.

FW3B.3 • 13:30 Invited
Heterogeneous Integration of GaAs/AlGaAs Devices for Non-Linear Applications, Marc Sorel[1], Stuart May[1], Matteo Clerici[1], Michael Kues[1], Charalambos Klitis[1], Michael Strain[2], Benoit Guilhabert[2], John McPhillimy[2], Cosimo Lacava[3], Periklis Petropoulos[3]; [1]*Univ. of Glasgow, UK;* [2]*Univ. of Strathclyde, UK;* [3]*Univ. of Southampton, UK.* We will review recent progress on the integration of AlGaAs devices for non-linear applications. Second harmonic generation on AlGaAs-on-insulator waveguides and the integration of AlGaAs microdisk resonators on silicon by transfer printing will be discussed.

FW3B.4 • 14:00
Enhanced nonlinearity in lithium niobate on insulator (LNOI) waveguides through engineering of lateral leakage, Andreas Boes[1,2], Lin Chang[2], Thach Nguyen[1], Markus Knoerzer[1], Jon Peters[2], John Bowers[2], Arnan Mitchell[1]; [1]*Royal Melbourne Inst. of Technology, Australia;* [2]*Univ. of Califonia, Santa Barbara, USA.* We present that the nonlinear optical conversion efficiency in LNOI ridge/rib waveguides can be improved by considering the lateral leakage at the second harmonic wavelength, enabling an improved nonlinear optical conversion efficiency of ~780% $W^{-1}cm^{-2}$.

Executive Ballroom 210C

13:00–15:00
FW3C • Generation & Control of Light Emission at the Nanoscale
Presider: Christian Haffner; NIST, USA

FW3C.1 • 13:00
Light Emission from a Waveguide Integrated MOS Tunnel Junction, Michael Doderer[1], Markus Parzefall[1], Andreas Joerg[1], Daniel Chelladurai[1], Nikola Dordevic[1], Yuriy Fedoryshyn[1], Amit K. Agrawal[2,3], Henri Lezec[2], Lukas Novotny[1], Juerg Leuthold[1], Christian Haffner[1]; [1]*ETH Zurich, Switzerland;* [2]*National Inst. of Standards and Technology, USA;* [3]*Univ. of Maryland, USA.* We report on light generation via inelastic electron tunneling in a metal-oxide-semiconductor (MOS) junction that is directly integrated within a silicon photonic waveguide. We generate an optical power of 6.8 pW.

FW3C.2 • 13:15
Polariton electroluminescence in monolayer WS_2, Biswanath Chakraborty[1], Jie Gu[1], Mandeep Khatoniar[1], Vinod Menon[1]; [1]*Physics, The City College of New York, CUNY, USA.* We demonstrate a room temperature polariton LED using monolayer WS_2 embedded in a microcavity in the strong coupling regime. Electrical injection is accomplished via graphene contacts and hBN tunnel barriers integrated with the microcavity.

FW3C.3 • 13:30 Invited
Spatial and Temporal Coherence of Ultrafast Plasmon Nanolasers, Teri W. Odom[1]; [1]*Northwestern Univ., USA.* This talk will describe the underlying mechanisms for coherence in two plasmonic nanolasing systems with different cavity structures: nanoparticle arrays and bowtie-shaped particles.

FW3C.4 • 14:00
Probing Electro-Magnetic Local Density of Optical States with Mixed ED-MD Emitters, Dongfang Li[1,2], Sinan Karaveli[1], Sebastien Cueff[1,3], Wenhao Li[1], Rashid Zia[1]; [1]*Brown Univ., USA;* [2]*Center for Integrated Nanotechnologies, Los Alamos National Lab, USA;* [3]*Institut des Nanotechnologies de Lyon, France.* We experimentally demonstrated that the lifetime of quantum emitters with strongly mixed electric dipole (ED) and magnetic dipole (MD) transitions can directly probe the combined electro-magnetic local density of optical states.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

13:00–15:00
FW3D • Topological Photonics III
Presider: To Be Announced

FW3D.1 • 13:00
Towards a Non-magnetic Topological Haldane Laser, Yuzhou Liu[1], Pawel Jung[1,2], Midya Parto[1], Jason Leshin[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; *[1]Univ. of Central Florida, CREOL, USA; [2]Faculty of Physics, Warsaw Univ. of Technology, Poland.* We introduce a new design for implementing the topological Haldane laser on a non-magnetic platform. Unit cells are provided for detuned nearest neighbor coupling and imaginary next-nearest neighbor coupling based on microring laser networks.

FW3D.2 • 13:15
Mode-locked topological laser in synthetic dimensions, Zhaoju Yang[1], Eran Lustig[1], Gal Harari[1], Yonatan Plotnik[1], Miguel Bandres[1], Mordechai Segev[1]; *[1]Technion - Israel Inst. of Technolo, Israel.* We present topological insulator laser with one spatial and one modal dimensions. The topological lasing state imposes constant phase difference between the multi-frequency modes, forcing the resonators to mode-lock and emit short pulses.

FW3D.3 • 13:30
Observation of Flat-band Line States in Photonic Super-honeycomb Lattices, Wenchao Yan[1], Daohong Song[1], Shiqi Xia[1], Liqin Tang[1], Yiqi Zhang[1], Jingjun Xu[1], Zhigang Chen[1,2]; *[1]The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China; [2]San Francisco State Univ., USA.* We demonstrate for the first time photonic super-honeycomb lattices established with a cw-laser writing technique, thereby uncovering two different types of flat-band line states that manifest noncontractible-loop-states in infinite flat-band systems arising from real-space topology.

FW3D.4 • 13:45
Fractal Waveguide Arrays Induce Maximal Anderson Localization, Jonathan Guglielmon[1], Mikael C. Rechtsman[1]; *[1]Pennsylvania State Univ., USA.* In recent years, there has been great interest in using Anderson localization or flat-band lattices to eliminate interwaveguide crosstalk for imaging and telecommunications applications. We show that fractal configurations offer strict improvements on these schemes.

FW3D.5 • 14:00
Realization of a Non-Quantized Square-Root Topological Insulator Based on Photonic Aharonov-Bohm Cages, Mark Kremer[1], Ioannis Petrides[2], Eric Meyer[1], Matthias Heinrich[1], Oded Zilberberg[2], Alexander Szameit[1]; *[1]Inst. of Physics, Univ. of Rostock, Germany; [2]Inst. for Theoretical Physics, ETH Zürich, Switzerland.* We report a new type of insulator that exhibits spectral bands with nonquantized topological properties. Furthermore, a quantisation manifests itself upon squaring the Hamiltonian. We experimentally verify our claims by using photonic Aharonov Bohm cages.

Executive Ballroom 210E

Executive Ballroom 210F

CLEO: Science & Innovations

13:00–15:00
SW3E • Ultrafast Metrology
Presider: Igor Jovanovic; Univ. of Michigan, USA

SW3E.1 • 13:00
Application of Artificial Neural Networks to Dispersion Scan Retrievals, Sven Kleinert[1], Ayhan Tajalli[1], Tamas Nagy[2], Uwe Morgner[1,3]; *[1]Leibniz Universität Hannover, Germany; [2]Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany; [3]Laser Zentrum Hannover e.V., Germany.* We present the phase reconstruction of ultrashort pulses from dispersion scan traces using a deep neural network. Compared to conventional algorithms, this reconstruction is more than 3000 times faster, enabling video-rate reconstructions.

SW3E.2 • 13:15
Sensitive Interferometric GRENOUILLE Device, Travis N. Jones[1], Peter Šušnjar[2], Rok Petkovšek[2], Rick Trebino[1]; *[1]Georgia Inst. of Technology, USA; [2]Lab for Photonics and Laser Systems, Univ. of Ljubljana, Slovenia.* We introduce a practical, sensitive and self-referenced frequency-resolved optical gating technique for measuring picosecond pulses with femtojoule energies. We demonstrate the capability of this technique to measure a pulse with complex temporal and spectral structure.

SW3E.3 • 13:30 Invited
Controlling the Velocity of Ultrashort Laser Bursts in Vacuum, Fabien Quéré[1]; *[1]CEA Saclay, France.* This talk will present the intriguing new possibilities offered by spatio-temporal shaping of ultrashort laser beams, and some of the latest developments on the spatio-temporal metrology of femtosecond lasers, up to the PetaWatt power level.

SW3E.4 • 14:00
Coherent Two-Octave-Spanning Supercontinuum Generation in Lithium-Niobate Waveguides, Mengjie Yu[1], Boris Desiatov[1], Yoshitomo Okawachi[2], Alexander Gaeta[2], Marko Lončar[1]; *[1]Harvard Univ., USA; [2]Applied Physics and Applied Math, Columbia Univ., USA.* We demonstrate a coherent supercontinuum spanning two octaves with 35 pJ pulses in a lithium-niobate waveguide under the presence of second- and third-order nonlinear effects, which allows for detection of the carrier-envelope offset frequency on-chip.

13:00–15:00
SW3F • Terahertz Plasmonics
Presider: Vedran Jelic; Michigan State Univ., USA

SW3F.1 • 13:00
Tunable magneto-optical polarization device for terahertz waves based on InSb plasmonic structure, Qianyi Mu[1], Fei Fan[1], Jierong Cheng[1], Shengjiang Chang[1]; *[1]Nankai Univ., China.* We demonstrated the InSb magneto-plasmonics for THz polarization conversion. The magneto-optical enhancement mechanisms were found, achieving broadband perfect orthogonal linear polarization conversion modulated by the weak magnetic field in the experiment.

SW3F.2 • 13:15
Magnetoplasmonic Manipulation of THz Transmission and Faraday Rotation Using Graphene Micro-Ribbon Arrays, Prashant Padmanabhan[1], Stéphane Boubanga-Tombet[2], Taiichi Otsuji[3], Rohit Prasankumar[1]; *[1]Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; [2]Telops Inc., Canada; [3]Research Inst. of Electrical Communication, Tohoku Univ., Japan.* We utilize periodic arrays of graphene micro-ribbons to control the transmission and Faraday rotation spectra of THz pulses by coupling to magnetoplasmon modes whose frequencies are determined by the ribbon width.

SW3F.3 • 13:30 Invited
Terahertz Spectroscopy of Dirac Plasmons: Graphene and Topological Insulators, Hyunyong Choi[1]; *[1]Yonsei Univ., South Korea (the Republic of).* Dirac materials like graphene and three-dimensional topological insulators exhibit strong low-energy light-matter interactions. Here I will review recent progresses of terahertz spectroscopy studies of such Dirac materials both in quasi-equilibrium and non-equilibrium limits.

SW3F.4 • 14:00
0.25 mW Pulsed Terahertz Radiation from Bias-Free, Telecommunication-Compatible Plasmonic Nanoantennas, Deniz Turan[1], Nezih Tolga Yardimci[1], Mona Jarrahi[1]; *[1]Univ. of California, Los Angeles, USA.* We present a bias-free, telecommunication-compatible photoconductive terahertz source, which offers radiation powers exceeding 0.25 mW, enabling time-domain terahertz spectroscopy with more than a 90 dB dynamic range over a 0.1-3.5 THz bandwidth.

Executive Ballroom 210G | Executive Ballroom 210H | Meeting Room 211 A/B

CLEO: Science & Innovations

CLEO: Applications & Technology

13:00–15:00
SW3G • Frequency Combs & Stable Laser Systems
Presider: Ladan Arissian; NRC, USA

SW3G.1 • 13:00
Narrow-linewidth and highly stable optical frequency comb realized with a simple servo control system in a mode-locked Er:fiber laser, Kazumichi Yoshii[1,4], Yu Asahina[1,4], Yuko Yamada[1,4], Yusuke Hisai[1,4], Sho Okubo[2,4], Masato Wada[2,4], Hajime Inaba[2,4], Takemi Hasegawa[3], Yoshinori Yamamoto[3], Feng-Lei Hong[1,4]; [1]*Yokohama National Univ., Japan;* [2]*National Metrology Inst. of Japan, Japan;* [3]*Sumitomo Electric Industries, Japan;* [4]*JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, Japan.* We developed a mode-locked Er:fiber laser containing a small optical bench with an electro-optic modulator. The bench is used to control the laser repetition frequency at a large servo bandwidth and realize narrow linewidth.

SW3G.2 • 13:15
Stabilized All-Fiber-Based Mode-Filtering Technique for the Generation of a GHz-Repetition-Rate Frequency Comb, Yoshiaki Nakajima[1,2], Takuya Hariki[1,2], Akiko Nishiyama[1,2], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan.* An all-fiber-based mode-filtering technique is developed for generating a 1 GHz fiber-based frequency comb with a multiplication factor of 21. A high side-mode suppression ratio of approximately of 38 dB is achieved with this comb.

SW3G.3 • 13:30
Broad Visible Frequency Comb with 24-GHz Mode-spacing Based on Mode-Locked Erbium-Fiber Laser, Keisuke Nakamura[1,2], Sho Okubo[1,2], Ken Kashiwagi[1,2], Hajime Inaba[1,2]; [1]*National Metrology Inst. of Japan, Japan;* [2]*JST ERATO, MINOSHIMA Intelligent Optical Synthesizer, Japan.* We developed a 24-GHz spacing comb based on a mode-locked Er-fiber laser and mode-filtering technique. The broad comb spectrum in infrared region was converted to visible region by a PPLN waveguide.

SW3G.4 • 13:45
High-Coherence Ultra-Broadband Dual-Comb Fiber Laser with Carrier-Envelope-Offset Frequency, Yoshiaki Nakajima[1,2], Yuya Hata[1,2], Yugo Kusumi[1], Kaoru Minoshima[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, Japan.* A dual-comb fiber laser that generates two high-coherence, ultra-broadband frequency combs with slightly different repetition rates was developed. Carrier-envelope-offset beat signals with a high signal-to-noise-ratio of 30 dB were demonstrated with high controllability.

SW3G.5 • 14:00
Full Stabilization of 1.5-W Kerr-Lens Mode-Locked Yb:CYA Laser Frequency Comb, Ziyue Zhang[1,2], Hainian Han[1,2], Huibo Wang[3], Xiaodong Shao[1], Zhiyi Wei[1,2]; [1]*Inst. of Physics, CAS, China;* [2]*Univ. of Chinese Academy of Science, China;* [3]*School of Physics and Optoelectronics Engineering, Xidian Univ., China.* We report a fully stabilized 1.5-W kerr-lens mode-locked Yb:CYA laser frequency comb. Integrated phase noise of the stabilized carrier-envelope offset frequency is 370mrad, frequency deviation for more than 3-hours is observed to be 0.8 mHz.

13:00–15:00
SW3H • Nonlinear Optical Phenomena
Presider: Markku Vainio University of Helsinki, Finland

SW3H.1 • 13:00
Four-wave mixing in orbital angular momentum modes, Xiao Liu[1], Erik N. Christensen[1,2], Gautam Prabhakar[1], Karsten Rottwitt[2], Siddharth Ramachandran[1]; [1]*Boston Univ., USA;* [2]*DTU fotonik, Technical Univ. of Denmark, Denmark.* We report the first, to our knowledge, demonstration of four-wave mixing between fiber modes carrying orbital angular momentum. We show that spin and orbital angular momentum conservation rules lead to diverse phase matching possibilities.

SW3H.2 • 13:15
Fiber event horizon by single color pump, Surajit Bose[1], Oliver Melchert[1,2], Ihar Babushkin[1], Mrinmay Pal[4], Günter Steinmeyer[3], Uwe Morgner[1], Ayhan Demircan[1,2]; [1]*Leibniz Univ. Hannover, Germany;* [2]*Hannover Centre for Optical Technologies, Germany;* [3]*Max-Born-Inst., Germany;* [4]*CSIR-Central Glass and Ceramic Research Inst., India.* We demonstrate both numerically and experimentally the direct creation of an optical event horizon that arises from the interaction of a solitary optical pulse with a group-velocity-matched dispersive wave.

SW3H.3 • 13:30
Temporal Tweezing of Polarization Domain Walls in a Fiber Kerr Resonator, Julien Fatome[1], Nicolas Berti[1], Bertrand Kibler[1], Bruno Garbin[2], Stuart Murdoch[2], Miro J. Erkintalo[2], Stephane Coen[2]; [1]*CNRS - Universite Bourgogne Franche Comté, France;* [2]*Univ. of Auckland, New Zealand.* We report the experimental demonstration of temporal trapping of polarization domain walls (PDWs) stored in a fiber Kerr resonator. The PDWs are trapped into specific time slots through a phase-modulation scheme of the holding beam.

SW3H.4 • 13:45
Spectral Magnification System for All-Optical WDM Grid Manipulation in Dispersion Un-Compensated Transmission, Frederik Klejs[1], Mads Lillieholm[1], Michael Galili[1], Leif K. Oxenløwe[1]; [1]*FOTONIK, DTU, Denmark.* We investigate spectral magnification as a tool for optical spectral grid manipulation in dispersion un-compensated communication systems. The presence of dispersion can be utilized to circumvent the need for temporal synchronization of pumps and signal.

SW3H.5 • 14:00
Measurement of Optical Pulsewidth in the Picosecond Regime Using a Non-linear Fiber and Power Meter, Umair Ahmed Korai Baloch[1,2], Zifei Wang[3], Cosimo Lacava[5], Lawrence Chen[3], Michael Strain[4], Ivan Glesk[1]; [1]*Dept. of Electronic and Electrical, Univ. of Strathclyde, UK;* [2]*Dept. of Telecommunication Engineering, Mehran Univ. of Engineering and Technology, Jamshoro, Pakistan, Pakistan;* [3]*Dept. of Electrical and Computer Engineering, McGill Univ., Canada;* [4]*Inst. of Photonics, Dept. of Physics, Univ. of Strathclyde, UK;* [5]*Optoelectronics Research Centre, Univ. of Southampton, UK.* A technique for the characterization of picosecond pulse widths is presented, based a non-linear optical fiber loop mirror and power meter measurement. Pulse-widths in the 2-10ps range are successfully recovered with a resolution of 0.25ps.

13:00–15:00
AW3I • Laser-formed Structures & Additive Manufacturing
Presider: Jie Qiao; Rochester Institute of Technology, USA

AW3I.1 • 13:00 Invited
A New Dimension in Silicon: "in-chip" Photonic Devices and 3D Micro-structures Enabled with Nonlinear Laser Lithography, Onur Tokel[1]; [1]*Dept. of Physics, Bilkent Univ., Turkey.* I will start by introducing the first buried (in-chip) photonic elements in silicon, followed by 3D laser-sculpting of the chip for industrial applications. I will finish by reviewing potential expansion to other semiconductors.

AW3I.2 • 13:30
Enlarged color gamut by transferring silicon nanowire arrays embedded in flexible polymer on nanoresonator, YeongJae Kim[1], Young Jin Yoo[1], Gil Ju Lee[1], Dong-Wook Lee[2], Dong Eun Yoo[2], Vantari Siva[1], Hansung Song[1], Il Suk Kang[2], Young Min Song[1]; [1]*Gwangju Inst. of Science and Technol, South Korea (the Republic of);* [2]*South Korea Advanced Inst. of Science and Technology, South Korea (the Republic of).* Enlarged color gamut with silicon nanowire arrays is demonstrated both theoretically and experimentally. These structures are comprised of a polymer embedded silicon nanowire arrays (Si NWAs) that are stacked on a metal/insulator/metal (MIM) nanoresonator.

AW3I.3 • 13:45
Additive Fabrication of Multiscale Metasurface by Electrohydrodynamic Nanotexturing of Two-Beam Interference-Patterned Photopolymer Surface, Qiang Li[1], In Ho Cho[1], Rana Biswas[1], Jaeyoun Kim[1]; [1]*Iowa State Univ., USA.* Adding nanotextures to polymer surfaces already corrugated by 2-beam interference lithography is highly challenging. Using softlithography, triboelectricity, and electrohydrodynamic lithography, we fabricate multiscale metasurfaces by adding nanovolcanoes to sinusoidally corrugated NOA73 surfaces.

AW3I.4 • 14:00
Additive Manufacturing of Fused Silica Glass Using Direct Laser Melting, Jincheng Lei[1], Yuzhe Hong[2], Qi Zhang[1], Fei Peng[2], Hai Xiao[1]; [1]*Clemson Univ. COMSET, USA;* [2]*Dept. of Materials Science and Engineering, Clemson Univ., USA.* A direct method for additive manufacturing of fused silica glass without any post treatment has been developed. By applying laser to process the fused silica paste, three-dimensional fused silica glass with high transparency was obtained.

Meeting Room 211 C/D

CLEO: Science & Innovations

13:00–15:00
SW3J • Photonic Sensing & Mid-infrared Photonics
Presider: Vladimir Aksyuk; NIST, USA

SW3J.1 • 13:00 Tutorial
Photonic Crystal Devices for Sensing, Toshihiko Baba[1]; [1]*Yokohama National Univ., Japan.* Two photonic crystal (PC) devices will be presented. The PC nanolaser detects electro-chemical effects, which allows ultrahigh sensitivity or spectral-analysis-free sensing. The PC slow light waveguide is used as a Tx/Rx optical antenna in LiDAR.

Toshihiko Baba received the Ph.D. degree from Yokohama National University in 1990. He became an associate professor and full professor in 1994 and 2005, respectively. He has presented the studies on ARROW waveguides, VCSELs, photonic crystals, Si photonics, micro/nanolasers, slow light, etc. in 200 papers with 12900 citations.

SW3J.2 • 14:00
Mid-Infrared Computational Spectroscopy with an Electrically-Tunable Graphene Metasurface, Vivek R. Shrestha[4], Benjamin Craig[4], Matin Amani[1,3], James Bullock[2,1], Ali Javey[1,3], Kenneth Crozier[4,2]; [1]*Electrical Engineering and Computer Sciences, Univ. of California, Berkeley, Berkeley, USA;* [2]*Dept. of Electrical and Electronic Engineering, The Univ. of Melbourne, Australia;* [3]*Materials Sciences Division, Lawrence Berkeley National Lab, USA;* [4]*School of Physics, The Univ. of Melbourne, Australia.* We demonstrate graphene-plasmonic metasurfaces whose mid-infrared reflection spectra are electrically-tunable. Using measurements of the power reflected by the metasurfaces at different drive voltages, the source spectrum is computationally reconstructed by the recursive least squares method.

Meeting Room 212 A/B

CLEO: Applications & Technology

13:00–15:00
AW3K • Optical Solutions for Autonomous Driving
Presider: Fabio Di Teodoro, Raytheon SAS, USA

AW3K.1 • 13:00 Invited
Automotive LiDAR: Design Concepts and Challenges, Jake Li[1]; [1]*Hamamatsu Corporation, USA.* The presentation will briefly introduce different LiDAR concepts, discusses the techniques of measuring distance with light for the automotive industry based on principles of the direct time of flight (TOF) and indirect TOF – frequency modulated continuous wave (FMCW). The discussion contains the following topics: benefits and challenges of different TOF or FMCW LiDAR concepts in the market today; overview of optical design challenges that's key driver for development of each LiDAR concepts, as well as introducing key optical components (photodetector and light sources) for different LiDAR designs.

AW3K.2 • 13:30
Vernier Si-Photonic Phased Array Transceiver for Grating Lobe Suppression and Extended Field-of-View, Nathan Dostart[1], Michael Brand[1], Bohan Zhang[2], Daniel Feldkhun[1], Kelvin Wagner[1], Milos Popovic[2,1]; [1]*Electrical, Computer, and Energy Engineering, Univ. of Colorado at Boulder, USA;* [2]*Electrical and Computer Engineering, Boston Univ., USA.* We present a Vernier optical phased array transceiver architecture that suppresses grating lobes and can extend the field-of-view. The first experimental demonstration shows Vernier lobe suppression by transmitting from adjacent TX and RX tiles simultaneously.

AW3K.3 • 13:45
Discrete spectral-temporal encoded LiDAR, Yunshan Jiang[1], Sebastian Karpf[1], Bahram Jalali[1]; [1]*Univ. of California Los Angeles, China.* We propose the discrete spectro-temporal LiDAR that realizes non-mechanical scanning in one dimension at 0.342MHz line rate with a single laser and a single-pixel detector. Our implementation is based on an externally modulated FDML MOPA laser.

AW3K.4 • 14:00
Compound period grating coupler for double beams generation and steering, Dachuan Wu[1], Ya Sha Yi[1], Wei Guo[1]; [1]*Univ. of Michigan, USA.* We propose a compound period grating coupler by combining two component periods together to generate two outcoupling beams simultaneously. The two beams both response to the wavelength tuning, and thus approximately double the steering range.

Meeting Room 212 C/D

CLEO: Science & Innovations

13:00–15:00
SW3L • Ultrasound, Photoacoustic, & Photothermal Sensing
Presider: Todd Stievater, US Naval Research Laboratory, USA

SW3L.1 • 13:00
Shot-noise-limited optical sensing of ultrasound using pulse interferometry with a free-space Fabry-Pérot, Oleg Volodarsky[1], Yoav Hazan[1], Amir Rosenthal[1]; [1]*Technion- Israel Inst. of Technology, Israel.* We demonstrate shot-noise-limited interferometric sensing of ultrasound for optical powers up to 5 mW using an optical scheme based on a pulse laser, fiber stretcher, and free-space Fabry-Pérot.

SW3L.2 • 13:15
Optical phase modulated pulse interferometry for parallel multi-channel ultrasound detection, Yoav Hazan[1], Amir Rosenthal[1]; [1]*Technion- Israel Inst. of Technology, Israel.* Optical detection of ultrasound using high Q-factor resonators lack of scalable scheme. In this work, we present phase-modulated pulse interferometry, a scalable scheme, enabling interrogation of multiple resonators simultaneously.

SW3L.3 • 13:30
Sensitivity enhancement of silicon-photonics-based ultrasound sensor via BCB cladding, Resmi R. Kumar[1], Evgeny Hahamovich[1], Shai Tsesses[1], Yoav Hazan[1], Assaf Grinberg[1], Amir Rosenthal[1]; [1]*Technion- Israel Inst. of Technology, Israel.* Low photo-elastic response of SOI sensors limits the development of optical detection of ultrasound. We demonstrate ultrasound sensitivity enhancement in silicon waveguides by BCB over-cladding replacing Silica.

SW3L.4 • 13:45
An Integrated Broadband Ultrasound Sensor based on a Photonic Crystal Slab, Eric Y. Zhu[1], Maria C. Charles[1], Cory Rewcastle[1], Raanan Gad[1], Li Qian[1], Ofer Levi[1]; [1]*Univ. of Toronto, Canada.* A CMOS-compatible photonic crystal slab (PCS) sensor is used to detect ultrasound signals in water. The range of detection spans 160 kPa down to a noise-equivalent pressure (NEP) of 650 Pa (3.7 Pa/rt Hz). The detection bandwidth spans 1 to 38 MHz, limited only by our measurement apparatus.

SW3L.5 • 14:00
Optical Frequency Comb Photoacoustic Spectroscopy, Ibrahim Sadiek[1], Tommi Mikonnen[2], Markku M. Vainio[2,3], Juha Toivonen[2], Aleksandra Foltynowicz[1]; [1]*Dept. of Physics, Umea Univ., Sweden;* [2]*Lab of Photonics, Tampere Univ. of Technology, Finland;* [3]*Dept. of Chemistry, Univ. of Helsinki, Finland.* We combine for the first time a mid-infrared optical frequency comb Fourier transform spectrometer with cantilever-enhanced photoacoustic detection and measure high-resolution broadband spectra of the fundamental band of methane in a few milliliter sample volume.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

13:00–15:00
FW3M • Ultrafast Spectroscopy in 2D Materials & Heterostructures
Presider: Mackillo Kira; University of Michigan, USA

FW3M.1 • 13:00
Internal Structure and Ultrafast Dynamics of Tailored Excitons in van der Waals Heterostructures, Philipp Steinleitner[1], Philipp Merkl[1], Philipp Nagler[1], Christian Schüller[1], Tobias Korn[1], Samuel Brem[2], Malte Selig[3], Gunnar Berghäuser[3], Ermin Malic[2], Rupert Huber[1]; [1]*Physics, Univ. of Regensburg, Germany;* [2]*Physics, Chalmers Univ. of Technology, Sweden;* [3]*Theoretical Physics, Technical Univ. of Berlin, Germany.* Phase-locked few-cycle mid-infrared pulses trace how a capping layer of hexagonal boron nitride renormalizes the internal structure of photoexcited excitons in a WSe_2 monolayer and how dark excitons form from initially bright species.

FW3M.2 • 13:15
Direct Measurement of Coherent Coupling in a $MoSe_2$/WSe_2 Heterostructure, Hanna G. Ruth[1], Eric Martin[1], Torben L. Purz[1,2], Pasqual Rivera[3], Xiaodong Xu[3], Steven T. Cundiff[1]; [1]*Univ. of Michigan, USA;* [2]*Physics, Univ. of Gottingen, Germany;* [3]*Univ. of Washington, USA.* We use multidimensional coherent spectroscopy to identify interlayer coherent coupling between excitons in a MoSe2/WSe2 heterostructure, which brings us towards the goal of resolving energy transfer processes in transition metal dichalcogenide heterostructures.

FW3M.3 • 13:30 Invited
Evidence for Moiré Excitons in Van der Waals Heterostructures, Xiaoqin Li[1]; [1]*Univ. of Texas at Austin, USA.* Stacking two monolayers of vdW materials, lattice mismatch or rotational misalignment introduces an in-plane moiré superlattice. In this talk, I discuss how a moiré superlattice may influence the optical properties of transition metal dichalcogenide heterostructures.

FW3M.4 • 14:00
Excitonic Effects in Single Layer MoS_2 Probed by Broadband Two-dimensional Electronic Spectroscopy, Margherita Maiuri[1], Stefano dal Conte[1], Mattia Russo[1], Junjia Wang[2], Giancarlo Soavi[2], Dumitru Dumcenco[3], Andras Kis[3], Malte Selig[4], Sandra Khun[4], Marten Richter[4], Andreas Knorr[4], Andrea C. Ferrari[2], Giulio Cerullo[1]; [1]*Politecnico di Milano, Italy;* [2]*Cambridge Graphene Centre, Univ. of Cambridge, UK;* [3]*Electrical Engineering Inst., Ecole Polytechnique Federale de Lausanne, Switzerland;* [4]*Technische Universität Berlin, Germany.* We exploit two-dimensional electron spectroscopy to coherently excite the A and B excitons in monolayer MoS_2. Combined with simulations, our data distinguish ultrafast bright excitons decoherence and sub-ps scattering decays to dark excitons.

Marriott
Salon III

CLEO: Science & Innovations

13:00–15:00
SW3N • Cascade Lasers
Presider: David Burghoff; Univ. Notre Dame, USA

SW3N.1 • 13:00 Invited
Novel Interband Cascade Lasers for the Mid-Infrared, James Gupta[1]; [1]*National Research Council Canada, Canada.* We report the latest developments in interband cascade lasers (ICLs) for high-performance, low power-consumption mid-IR sensing applications: type-I ICLs on GaSb for the 3um-range and long-wavelength InAs-based type-II ICLs.

SW3N.2 • 13:30
Square Wave Emission in a Mid-infrared Quantum Cascade Oscillator Under Rotated Polarization, Olivier Spitz[1,3], Andreas Herdt[2], Mathieu Carras[3], Wolfgang Elsässer[2], Frederic Grillot[1,4]; [1]*Télécom ParisTech, France;* [2]*Technische Universität Darmstadt, Germany;* [3]*mirSense, France;* [4]*Univ. of New Mexico, USA.* Quantum cascade lasers, which are known to only emit a transverse-magnetic wave under free-running operation, can output a square wave with transverse-electric emission under polarization-rotated feedback.

SW3N.3 • 13:45
Catastrophic Degradation in High-Power Buried Heterostructure Quantum Cascade Lasers, Yongkun Sin[1], Zachary Lingley[1], Miles Brodie[1], B Knipfer[2], C Sigler[2], C Boyle[2], J D. Kirch[2], K Oresick[2], H Kim[2], D Botez[2], L Mawst[2], D Lindberg[3], T Earles[3]; [1]*The Aerospace Corporation, USA;* [2]*Univ. of Wisconsin – Madison, USA;* [3]*Intraband, LLC, USA.* Investigation of catastrophic degradation in high-power, buried-heterostructure quantum cascade lasers, using focused ion beam and high-resolution TEM techniques, has revealed dislocations generated, as a result of degradation, mostly in areas away from the active region.

SW3N.4 • 14:00 Invited
Terahertz Metasurface Quantum-cascade Lasers: Broadband and High-power Operation, Benjamin S. Williams[1]; [1]*Univ. of California Los Angeles, USA.* Metasurface based external cavity lasers are an attractive approach to the challenge of obtaining simultaneous high-power, tunable single-mode wavelength, and excellent beam pattern from terahertz quantum-cascade lasers.

Marriott
Salon IV

13:00–15:00
SW3O • Long Distance Transmission
Presider: Xi Chen; Nokia Corporation, USA

SW3O.1 • 13:00
Fiber Nonlinearity Compensation Using Erbium-Doped-Fiber-Assisted Dual-Order Raman Amplification, Mingming Tan[1], Mohammad Al-Khateeb[1], Tingting Zhang[1], Andrew Ellis[1]; [1]*Aston Univ., UK.* We propose a novel dual-order backward-pumped distributed Raman amplification scheme assisted by 25cm erbium-doped-fiber providing nearly perfect multi-span signal power symmetry and 7dB nonlinear threshold improvement for 256Gb/s inline transmission when deploying optical phase conjugation.

SW3O.2 • 13:15
Differential Phase Noise Properties in QD-MLL and its Performance in Coherent Transmission Systems, Mustafa A. Al-Qadi[1], Maurice O'Sullivan[2], Chongjin Xie[3], Rongqing Hui[1]; [1]*Univ. of Kansas, USA;* [2]*R&D, Ciena Corporation, Canada;* [3]*Alibaba Infrastructure Service, Alibaba Group, Sunnyvale, CA 94085, USA, USA.* We show that the differential phase noise between adjacent comb lines in quantum-dot mode-locked lasers may exhibit higher phase noise impacts in coherent transmission systems than their apparent narrow linewidths, due to unique spectral profiles.

SW3O.3 • 13:30
Performance Evaluation of K-Means Clustering Assisted Common Phase Error Estimation, Qiulin Zhang[1], Chester Shu[1]; [1]*Chinese Univ. of Hong Kong, Hong Kong.* We demonstrate that common phase error can be estimated by k-means clustering with just 4 clusters for different modulation formats. Performance comparison between Viterbi-Viterbi algorithm and k-means clustering is conducted in a Kramers-Kronig detection system.

SW3O.4 • 13:45
1,000-km Transmission of 1.5-Gb/s Y-00 Quantum Stream Cipher using 4096-level Intensity Modulation Signal, Fumio Futami[1], Ken Tanizawa[1], Kentaro Kato[1], Osamu Hirota[1]; [1]*Tamagawa Univ., Japan.* A real-time 1.5-Gb/s Y-00 quantum stream cipher transmission for secure optical communication is experimentally demonstrated. An error-free (BER $< 10^{-9}$) transmission of 4096-level intensity-modulation cipher signals is achieved in a dispersion-managed link over 1,000 km.

SW3O.5 • 14:00 Invited
Modeling and Mitigation of Nonlinear Effects in Uncompensated Coherent Optical Transmission Systems, Gabriella Bosco[1]; [1]*Politecnico di Torino, Italy.* We review recent results on analytical modeling of non-linear interference in multi-span optical systems with high-order modulation and coherent detection, and on performance gains that can be achieved through non-linearity mitigation in digital coherent receivers.

CLEO: Applications & Technology

13:00–15:00
AW3P • A&T Topical Review on Progress in the Semiconductor Laser Technology II

AW3P.1 • 13:00 Invited
DFB Interband Cascade Laser Arrayfor Mid Infrared Spectroscopy, Sven Höfling[1,2], Julian Scheuermann[3], Robert Weih[3], Martin Kamp[1], Johannes Koeth[3]; [1]*Universität Würzburg, Germany;* [2]*Univ. of St Andrews, UK;* [3]*nanoplus GmbH, Germany.* We demonstrate an interband cascade laser array with multiple spectrally monomode emitters monolithically integrated on a single chip. The targeted emission wavelengths cover the mid infrared regime from around 3.3 to 3.5 microns.

AW3P.2 • 13:30
High Brightness Operation in Broad Area Quantum Cascade Lasers with Reduced Number of Stages, Matthew Suttinger[1], Rowel Go[1], Ahmad Azim[1], Enrique Sanchez[1], Hong Shu[1], Arkadiy Lyakh[1]; [1]*Univ. of Central Florida, USA.* Two 20 µm wide QCL structures demonstrate room temperature watt-level CW power with single lobed behavior. A figure of merit predicts broad area, fundamental mode behavior configurations for QCLs of identical wavelength and stage height.

AW3P.3 • 13:45
Si-based Mid-Infrared GeSn-Edge-Emitting Laser with Operating Temperature up to 260 K, Yiyin Zhou[1,2], Wei Dou[1], Wei Du[4], Solomon Ojo[1,2], Huong Tran[1,3], Seyed Ghetmiri[5], Jifeng Liu[6], Greg Sun[7], Richard Soref[7], Joe Margetis[8], John Tolle[8], Baohua Li[3], Zhong Chen[1], Mansour Mortazavi[5], Shui-Qing Yu[1]; [1]*Dept. of Electrical Engineering, Univ. of Arkansas, USA;* [2]*Microelectronics-Photonics Program, Univ. of Arkansas, USA;* [3]*Arktonics, LLC, USA;* [4]*Dept. of Electrical Engineering, Wilkes Univ., USA;* [5]*Dept. of Chemistry and Physics, Univ. of Arkansas at Pine Bluff, USA;* [6]*Thayer School of Engineering, Dartmouth College, USA;* [7]*Dept. of Engineering, Univ. of Massachusetts Boston, USA;* [8]*ASM, USA.* We demonstrated optically pumped GeSn lasers with 20% maximum Sn content based on ridge waveguide with 5 and 20 µm ridge widths. The high operating temperature of 260 K was achieved with wider ridge device.

AW3P.4 • 14:00 Invited
Material Issues in GaN-based Laser Diode Manufacturing, Mike Leszczynski[1,2]; [1]*Inst. of High Pressure Physics, Poland;* [2]*TopGaN, Poland.* The first part of the talk will be devoted to blue and green laser diode applications: in lighting, RGB projectors, LiFi communication, quantum technologies and others. In the second part, I will present difficulties in growing AlGaInN. In particular, I will focus on point- and extended-defects.

13:00–15:00
AW3Q • A&T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors II

AW3Q.1 • 13:00
Reduction and Control of Edge Placement Error at the 5nm node Through a Holistic Approach. Robert Socha[1], [1]*ASML, USA.* Abstract note available.

AW3Q.2 • 13:30
Nanoscale Three-dimensional Patterning with Plasmonic Lithography. Jae W Hahn[1], [1]*Yonsei University, South Korea.* We fabricated nano-microscale 3D structures, such as a cone, microlens array, a nanoneedle, and a multiscale structure using a plasmonic lithography lithography system. The recent progress of the plasmonic lithography will be discussed.

AW3Q.3 • 14:00
Compensation of Optical Distortions in IC Fabrication. Yuri Granik[1], [1]*Mentor Graphics, USA.* Abstract not available.

Executive Ballroom 210A

Joint

JW3A • Sym on Coupling Artificial Atoms to Nano- & Opto-mechanical Systems I—Continued

JW3A.4 • 14:15
Strain control of silicon-vacancy centers in diamond nanophotonic devices, Stefan Bogdanovic[1], Bartholomeus Machielse[1], Srujan Meesala[1], Scarlett Gauthier[1], Graham Joe[1], Michelle Chalupnik[1], Jeffrey Holzgrafe[1], Cleaven Chia[1], Mikhail Lukin[1], Marko Loncar[1]; *[1]Harvard Univ., USA.* We present a nano-electromechanical platform for controlling optical transitions from spatially separated color centers in diamond waveguides. We use this technology to greatly suppress spectral diffusion and demonstrate entanglement between separate emitters.

JW3A.5 • 14:30
Dynamic Control of Spontaneous Emission Rate by Optomechanical Cavity QED System, Feng Tian[2,1], Hisashi Sumikura[2], Eiichi Kuramochi[2], Masato Takiguchi[2], Masaaki Ono[2], Akihiko Shinya[2], Masaya Notomi[2,1]; *[1]Tokyo Inst. of Technology, Japan; [2]NTT Basic Research Labs, Japan.* We demonstrate all-optical control of the spontaneous-emission rate within the emission lifetime in copper-doped-silicon nanobeam optomechanical cavities via mechanical oscillation driven by repetitive laser pulses, representing the first experimental realization of optomechanical cavity QED systems.

JW3A.6 • 14:45
Phonon-induced multi-color correlations in hBN single-photon emitters, Matthew Feldman[2,1], Claire Marvinney[1], Alex Puretzky[1], Lucas Lindsay[1], Ethan Tucker[1], Dayrl Briggs[1], Philip Evans[1], Richard F. Haglund[2], Benjamin Lawrie[1]; *[1]Oak Ridge National Lab, USA; [2]Vanderbilt Univ., USA.* We explore electron-phonon dynamics in hBN defects and observe $g^{(2)}(0)=0.20$ in a phonon replica and $g^{(2)}(0)=0.18$ between a phonon replica and the zero-phonon line, and we examine Purcell enhancement of phonon replicas with phononic cavities.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

FW3B • Chip-scale Nonlinear Optics—Continued

FW3B.5 • 14:15
Record High Squeezing Gain and Sensitivity in $\chi^{(2)}$-based AlGaAs Parametric Amplifiers, Zhizhong Yan[1], Haoyu He[1], Han Liu[1], Meng Iu[1], Osman Ahmed[1], Eric Chen[1], Youichi Akasaka[2], Tadashi Ikeuchi[2], Amr S. Helmy[1]; *[1]Univ. of Toronto, Canada; [2]Fujitsu Labs of America, USA.* Record squeezing, with squeezing parameter $r\approx2.5$ is measured in AlGaAs optical parametric amplifiers using an ultrafast pump centered at 775 nm. Polarization dependent squeezing and parametric gain were obtained with sub-photon per pulse amplifier sensitivity at 1550 nm regime.

FW3B.6 • 14:30
Laser Beat-Wave Induced Enhancement of the Kerr Nonlinearity in Bulk GaAs at 10µm, Daniel A. Matteo[1], Jeremy Pigeon[1], Sergei Tochitsky[1], Ulrich Huttner[2], Mackillo Kira[3], Stephan W. Koch[2,4], Jerome V. Moloney[4], Chan Joshi[1]; *[1]Dept. of Electrical Engineering, Univ. of California Los Angeles, USA; [2]Dept. of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; [3]Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA; [4]College of Optical Sciences, Univ. of Arizona, USA.* We experimentally and theoretically demonstrate enhancement of the Kerr nonlinearity in semi-insulating GaAs through four-wave mixing of a CO_2 laser beat-wave. Nonlinearity increases with decreasing beat frequency, attributed to nonlinear currents modulated by the beat-wave.

FW3B.7 • 14:45
Wide Bandwidth, Nonmagnetic Linear Optical Isolators based on Frequency Conversion, Tengfei Li[1], Kamal Abdelsalam[2], Sasan Fathpour[2], Jacob Khurgin[1]; *[1]Electrical and Computer Engineering, Johns Hopkins Univ., USA; [2]The College of Optics & Photonics, Univ. of Central Florida, USA.* We propose a family of nonmagnetic optical isolators based on waveguide frequency conversion and characterized by good isolation properties, high linearity, bandwidth as high as a few THz.

Executive Ballroom 210C

FW3C • Generation & Control of Light Emission at the Nanoscale—Continued

FW3C.5 • 14:15
Deterministic nanoprinting of single fluorescent molecules, Claudio U. Hail[1], Christian Höller[1], Korenobu Matsuzaki[2], Rohner Patrik[1], Jan Renger[2], Vahid Sandoghdar[2], Dimos Poulikakos[1], Hadi Eghlidi[1]; *[1]ETH Zürich, Switzerland; [2]Max Planck Inst. for the Science of Light, Germany.* We report direct non-contact electrohydrodynamic nanodrip printing of a countable number of photostable fluorescent molecules in a host crystal of nanoscopic dimensions with single molecule specificity, high spatial resolution and deterministic dipole orientation.

FW3C.6 • 14:30
nanoLED Wavelength Division Multiplexer Analysis, Sean M. Hooten[1], Nicolas M. Andrade[1], Seth A. Fortuna[1], Kevin Han[1], Ming Wu[1], Eli Yablonovitch[1]; *[1]Univ. of California Berkeley, USA.* Optical antennas can enhance the modulation bandwidth and output power of nanoscale LEDs. Here we analyze a wavelength division multiplexer that uses high Q optical antennas to further increase the total optical power.

FW3C.7 • 14:45
Waveguide Coupling of an Integrated Nanowire Laser on Silicon with Enhanced End-Facet Reflectivity, Jochen Bissinger[1], Daniel Ruhstorfer[1], Thomas Stettner[1], Gregor Koblmueller[1], Jonathan J. Finley[1]; *[1]Physic Dept., Walter Schottky Institut, Germany.* We numerically explored the coupling characteristics and the critical interplay with the end-facet reflectivities of nanowire lasers coupled to proximal silicon-waveguides. A proper waveguide design enables high coupling efficiencies with enhanced end-facet reflectivities of ~83%.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, *Exhibit Hall Theater I*

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FW3D • Topological Photonics III—Continued

FW3D.6 • 14:15
Wideband Slow Light in a Photonic Topological Insulator, Jonathan Guglielmon[1], Mikael C. Rechtsman[1]; [1]*Pennsylvania State Univ., USA.* We demonstrate that chiral edge states can be used to generate wideband slow light. This is achieved by producing an edge state that winds many times around the Brillouin zone as it crosses the bandgap.

FW3D.7 • 14:30
Magnetic Gauge Field for Photons in Synthetic Dimensions by a Propagation-Invariant Photonic Structure, Liat Nemirovsky[1], Moshe-Ishay Cohen[1], Eran Lustig[1], Mordechai Segev[1]; [1]*Technion, Israel.* We propose a system that exhibits an effective magnetic field for photons in synthetic - dimensions, implemented by a propagation-invariant (static) potential. The spectrum of this synthetic-space system displays Landau levels.

FW3D.8 • 14:45
Switching light at the interface between anomalous Floquet topological insulators, Francesco Piccioli[1], Lukas Maczewsky[1], Mark Kremer[1], Matthias Heinrich[1], Alexander Szameit[1]; [1]*Inst. of Physics, Univ. of Rostock, Germany.* We study interface states at the boundary between two Anomalous Floquet Photonic Topological Insulators and show how their interactions with an chiral edge mode can be used to switch it via the wave number.

Executive Ballroom 210E

CLEO: Science & Innovations

SW3E • Ultrafast Metrology—Continued

SW3E.5 • 14:15
Active *f*-to-2*f* interferometer for record-low jitter carrier-envelope phase locking, Ruoyu Liao[1,2], Haochen Tian[1], Tianli Feng[2], Youjian Song[1], Ming-lie Hu[1], Günter Steinmeyer[2,3]; [1]*Tianjin Univ., China;* [2]*Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany;* [3]*Humboldt Universität zu Berlin, Germany.* Introduction of optical gain into the infrared arm of *f*-to-2f interferometers is demonstrated to improve signal-to-noise ratios by > 20 dB. This opens a perspective for CEP stabilization of unstabilizable lasers.

SW3E.6 • 14:30
Single-shot CEP drift measurement at arbitrary repetition rate based on dispersive Fourier transform, Máté Kurucz[1], Szabolcs Tóth[1], Roland Flender[1], Ludovít Haizer[1], Balint Kiss[1], Benjamin Perseille[2], Eric Cormier[2]; [1]*ELI-ALPS, Hungary;* [2]*Centre Lasers Intenses et Applications, France.* Arbitrary repetition-rate single-shot CEP drift measurement technique is achieved based on dispersive Fourier transform. The technique is validated by comparing the results to an independent measurement. Further improvement is presented allowing jitter-free CEP drift extraction.

SW3E.7 • 14:45
Time-domain vectorial field reconstruction of a circularly polarized harmonic from silicon using 2D spectral shearing interferometry, Fabian Scheiba[1,2], Nicolai Klemke[1,2], Nicolas Tancogne-Dejean[1,3], Giulio Maria Rossi[1,2], Angel Rubio[1,3], Oliver D. Mücke[1,4], Franz Kartner[1,2]; [1]*Center for Free-Electron Laser Science CFEL, Deutsches Elektronen-Synchrotron DESY, Germany;* [2]*Physics Dept., Univ. of Hamburg, Germany;* [3]*Max Planck Inst. for the Structure and Dynamics of Matter, Germany;* [4]*The Hamburg Centre for Ultrafast Imaging, Germany.* A two-dimensional spectral shearing interferometry is demonstrated permitting to reconstruct vectorial optical fields with picojoule energy. As proof of principle, we retrieve the circularly polarized third-harmonic field emitted from 2-µm-thin silicon driven by 2.1-µm pulses.

Executive Ballroom 210F

SW3F • Terahertz Plasmonics—Continued

SW3F.5 • 14:15
Dielectric Membrane Mie-Resonant Metasurfaces, Quanlong Yang[1,2], Sergey S. Kruk[1], Yogesh K. Srivastava[3], Kirill Koshelev[1], Ranjan Singh[3], Jiaguang Han[2], Yuri S. Kivshar[1], Ilya Shadrivov[1]; [1]*Australian National Univ., Australia;* [2]*Tianjin Univ., China;* [3]*Nanyang Technological Univ., Singapore.* We introduce a novel concept of dielectric Mie-resonant membrane metasurfaces for the THz spectral region and fabricated from a free-standing silicon wafer. The metasurfaces support Mie resonances providing a 2π phase coverage and high transmission.

SW3F.6 • 14:30
Reconfigurable MEMS metasurface for active tuning of Fano resonance and logic gate operations at THz frequencies, Manukumara Manjappa[1,2], Prakash Pitchappa[1,2], Navab Singh[3], Nan Wang[3], Nikolay I. Zheludev[2,4], Chengkuo Lee[5], Ranjan Singh[1,2]; [1]*Division of Physics and Applied Physics, School of Physical and Mathematical Sciences,, Nanyang Technological Univ., Singapore;* [2]*Centre for Disruptive Photonic Technologies, The Photonics Inst.,, Nanyang Technological Univ., Singapore;* [3]*Inst. of Microelectronics, A-star Inst., Singapore;* [4]*Optoelectronics Research Centre and Centre for Photonic Metamaterials,, Univ. of Southampton, UK;* [5]*Dept. of Electrical & Computer Engineering, National Univeristy of Singapore, Singapore.* We experimentally show the excitation of sharp Fano resonances in a MEMS reconfigurable metasurface exhibiting multiple-input-output states in its electro-optical properties. Further, a set of composite logic gates such as exclusive-OR and XNOR are readout using THz pulse.

SW3F.7 • 14:45
500 GHz Plasmonic Mach-Zehnder Modulator, Maurizio Burla[1], Claudia Hoessbacher[1], Wolfgang Heni[1], Christian Haffner[1], Yuriy Fedoryshyn[1], Dominik Werner[1], Tatsuhiko Watanabe[1], Hermann Massler[2], Delwin L. Elder[3], Larry R. Dalton[3], Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland;* [2]*Fraunhofer IAF, Germany;* [3]*Dept. of Chemistry, Univ. of Washington, USA.* We experimentally demonstrate a plasmonic modulator for sub-THz applications, featuring – at the same time – a short length of 10s of micrometers, high linearity, and a record-high flat frequency response beyond 500 GHz.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, *Exhibit Hall Theater I*

Executive Ballroom 210G | Executive Ballroom 210H | Meeting Room 211 A/B

CLEO: Science & Innovations

SW3G • Frequency Combs & Stable Laser Systems—Continued

SW3G.6 • 14:15
Repetition-Rate Multiplication of Mode-locked Lasers Using Harmonic Injection Locking and Gain-Saturated SOA, Chan-Gi Jeon[1], Xiao-Zhou Li[1], Shilong Pan[2], Jungwon Kim[1]; [1]*South Korea Advanced Inst of Science & Tech, South Korea (the Republic of);* [2]*Nanjing Univ. of Aeronautics and Astronautics, China.* Low-noise repetition-rate multiplication method is proposed by combining harmonic injection locking and gain-saturated SOA. A 1-GHz optical pulse train with 33-dB side-mode-suppression-ratio, 3% modulation depth, and 6.3-fs absolute rms timing jitter [10kHz–1MHz] is demonstrated.

SW3G.7 • 14:30
Laser frequency stabilization at ≤10^{-16} from a thermal atomic beam, Judith Olson[1,2], Richard Fox[1], Tara M. Fortier[1], Chris Oates[1], Andrew Ludlow[1]; [1]*Optical Frequency Measurements, National Inst. of Standards and Technology, USA;* [2]*Physics, Univ. of Colorado Boulder, USA.* We describe a system for ultra-stable laser frequency generation using Ramsey-Borde interferometry with atomic calcium. Unprecedented frequency instabilities from a thermal ensemble are demonstrated.

SW3G.8 • 14:45
An iodine-stabilized laser at the telecom wavelength using a dual-pitch PPLN waveguide, Kohei Ikeda[1,3], Chaoyun Chen[1,3], Kazumichi Yoshii[1,3], Sho Okubo[2,3], Ken Kashiwagi[2,3], Hajime Inaba[2,3], Feng-Lei Hong[1,3]; [1]*Yokohama National Univ., Japan;* [2]*National Metrology Inst. of Japan, AIST, Japan;* [3]*JST, ERATO IOS, Japan.* We demonstrate third harmonic generation of a 1542-nm laser using a dual-pitch PPLN waveguide with a chirped polling period. The laser is used for saturation spectroscopy of molecular iodine at 514 nm.

SW3H • Nonlinear Optical Phenomena—Continued

SW3H.6 • 14:15
Power spectral density analysis of relative phase jitter in a twin-soliton molecule, Haochen Tian[1], Defeng Zhou[1], Yuwei Zhao[1], Youjian Song[1], Ming-lie Hu[1]; [1]*Tianjin Univ., China.* We characterized high-frequency relative phase jitter power spectral density of soliton molecules generated from a passively mode-locked Er:fiber laser based on tracking fast shifts of an spectral interference fringe.

SW3H.7 • 14:30
Enhancing SOI Waveguide Nonlinearities via Microring Resonators, Thomas Ferreira de Lima[1], Hsuan-Tung Peng[1], Mitchell A. Nahmias[1], Chaoran Huang[1], Siamak Abbaslou[1], Alexander N. Tait[1], Bhavin J. Shastri[1], Paul R. Prucnal[1]; [1]*Princeton Univ., USA.* All-optical devices can exploit a suite of nonlinearities in silicon photonics. We study how microring resonators (MRRs) harness these nonlinearities, with theoretical model and experimental validation. Free-carrier effects will practically always dominate Kerr in MRRs.

SW3H.8 • 14:45
Plasmonically Enhanced Nonlinear Generation via a Hybridized Nanopatch Antenna, Andrew J. Traverso[1], Tamra M. Nebabu[2], Virginia D. Wheeler[3], Maiken H. Mikkelsen[1,2]; [1]*Physics, Duke Univ., USA;* [2]*Electrical and Computer Engineering, Duke Univ. , USA;* [3]*USA Naval Research Lab, USA.* We demonstrate enhanced second harmonic generation by coupling an ultra-thin nonlinear dielectric into the gap-mode of the plasmonic nanopatch antenna. A 10^8-fold enhancement is achieved relative to the bare dielectric producing up to 3×10^7 photons/s.

CLEO: Applications & Technology

AW3I • Laser-formed Structures & Additive Manufacturing—Continued

AW3I.5 • 14:15
Absorptivity and energy scaling associated with laser powder bed fusion additive manufacturing, Manyalibo J. Matthews[1], Jianchao Ye[1], Leonidas Gargalis[2], Gabe Guss[1], Saad Khairallah[1], Alexander Rubenchik[1]; [1]*Lawrence Livermore National Lab, USA;* [2]*Univ. of Nottingham, UK.* In situ absorptivity measurements and finite element modeling are used to characterize energy coupling mechanisms and scaling behavior in laser powder bed fusion additive manufacturing. A universal relationship is derived that predicts melt depth and absorptivity.

AW3I.6 • 14:30
On-line Quantitative Analyzing of Molten Alloy Ingredient in Industrial Vacuum Smelting Process Using Laser-Induced Breakdown Spectroscopy, Zhao Tianzhuo[1,2], Xin Li[2,1], Qixiu Zhong[2,1], Hong Xiao[1], Shuzhen Nie[1], Fuqiang Lian[1], Sining Sun[3], Zhongwei Fan[1,2]; [1]*Academy of Opto-electronics, Chinese Academy of Sciences, China;* [2]*Academy of Opto-electronics, Univ. of Chinese Academy of Sciences, China;* [3]*Beijing GK Laser Technology Co., Ltd., China.* Laser-induced breakdown spectroscopy is used to quantitative analyze molten alloy ingredient in a 2-ton vacuum induction melt furnace. Measurements relative standard deviation of the main elements is 2~10%, trace element (< 0.2%) is lower than 25%.

AW3I.7 • 14:45
Laser Ignition of Cryogenic Propellants in Space Propulsion, Robert G. Stützer[1], Jan Deeken[1], Justin Hardi[1], Dmitry Suslov[1], Michael Börner[1], Michael Oschwald[1]; [1]*German Aerospace Center, Germany.* A Q-switched laser system was applied to a research rocket combustor in order to ignite cryogenic propellants by inducing several plasma breakdown events. The optical emission was analyzed using LIBS and other techniques.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, *Exhibit Hall Theater I*

Meeting Room 211 C/D

CLEO: Science & Innovations

SW3J • Photonic Sensing & Mid-infrared Photonics—Continued

SW3J.3 • 14:15
InSb Nanostructures as selective absorbers in the Short and Mid-Wave Infrared, Nicholas Collins[1], Amit Solanki[1], Han-Don Um[1], Ruizhi Huang[1], Fawwaz Habbal[1]; [1]*Harvard Univ., USA.* We demonstrated through a series of electromagnetic simulations and FTIR measurements a proof of concept for using vertically aligned arrays of InSb nanostructures as devices for selective SWIR and MWIR light absorption.

SW3J.4 • 14:30
Suspended group III-V waveguides integrated on silicon substrates for mid-infrared photonics, Jeff Chiles[1], Eric J. Stanton[1], Nima Nader[1], Jeff Shainline[1], Sae Woo Nam[1], Richard P. Mirin[1]; [1]*NIST, USA.* We demonstrate wafer-scale integration of suspended $Al_{0.32}Ga_{0.68}As$ nanophotonic waveguides on silicon substrates. Micro-ring resonators are fabricated and measured at λ = 1545 and 2305 nm, showing loaded quality factors of 740,000 and 450,000, respectively.

SW3J.5 • 14:45
Hyperuniform Disordered Polarisers for the Mid-Infrared, Milan Milosevic[1], Wen Zhou[2], Hon Ki Tsang[2], Ahmed Osman[1], Stevan Stankovic[1], Yanli Qi[1], Milos Nedeljkovic[1], Zhibo Qu[1], Xingzhao Yan[1], Ali Khokhar[1], Graham T. Reed[1], Goran Mashanovich[1]; [1]*Zepler Inst. for Photonics and Nanoelectronics, Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong.* We report on the design, fabrication and characterisation of silicon-on-insulator hyperuniform disordered polarisers at mid-infrared wavelengths. Small device footprint and large operational bandwidth revealed great potential of hyperuniform disordered platform for integrated photonics.

Meeting Room 212 A/B

CLEO: Applications & Technology

AW3K • Optical Solutions for Autonomous Driving—Continued

AW3K.5 • 14:15
Mid-Infrared 2-D Beam Steering, Jason Midkiff[1], Swapnajit Chakravarty[2], Kyoung Min Yoo[1], Ray T. Chen[1,2]; [1]*Univ. of Texas, USA;* [2]*Omega Optics, USA.* We will experimentally demonstrate optical beam steering in the mid-IR spectral region (around l=4.6mm) in the InP/InGaAs platform. Both wavelength and phase tuning are utilized for two-dimensional (2D) steering in elevation and azimuthal directions respectively.

AW3K.6 • 14:30
A High-Compactness Electrically Controlled Beam-Steering Chip , Guanzhong Pan[1], Chen Xu[1], Yiyang Xie[1], Yibo Dong[1], Qiuhua Wang[1], Hongda Chen[2]; [1]*Beijing Univ. of Technology, China;* [2]*Inst. of Semiconductor, Chinese Academy of Sciences, China.* A novel high-compactness electrically controlled beam-steering chip was achieved via integrating a liquid crystal optical phased array directly on a coherently coupled VCSEL array. One-dimensional beam steering was successfully realized by the chip.

AW3K.7 • 14:45
Multi-order Laser Beam Steering with Digital Micro Mirror Device for High-speed LIDARs, Joshua M. Rodriguez[1], Brandon Hellman[1], Braden Smith[1], Heejoo Choi[1], Dae Wook Kim[1], Yuzuru Takashima[1]; [1]*Univ. of Arizona, USA.* Multi-order DMD based beam steering enables a fast beam steering that scan rate exceeds a frame rate of DMD, over tens of KHz, by redirecting laser pulses to multiple directions within couple of ms timeframe.

Meeting Room 212 C/D

CLEO: Science & Innovations

SW3L • Ultrasound, Photoacoustic, & Photothermal Sensing—Continued

SW3L.6 • 14:30
Photoacoustic spectrometer based on widely tunable mid-infrared pulsed optical parametric, Mikael Lassen[1], Laurent Lamard[2], David Balslev-Harder[1], Jan Petersen[1], Andre Peremans[2]; [1]*Danish Fundamental Metrology, Denmark;* [2]*Laserspec BVBA, 15 rue Trieux Scieurs, B-5020 Malonne, Belgium, Belgium.* We demonstrate the usefulness of a nanosecond pulsed mid-infrared optical parametric oscillator for Photoacoustic spectroscopic measurements. Spectroscopic trace-gas measurements are demonstrated targeting environmental monitoring and breath gas analysis.

SW3L.7 • 14:45
Single-molecule Optical Absorption Imaging by Nanomechanical Photothermal Sensing at Room Temperature, Miao-Hsuan Chien[1], Mario Brameshuber[2], Benedikt Rossboth[2], Gerhard Schütz[2], Silvan Schmid[1]; [1]*Inst. of sensor and actuator system, TU Wien, Austria;* [2]*Inst. of applied physics, TU Wien, Austria.* A novel nanomechanical absorption-based microscopy with unprecedented sensitivity of 16 $fW/Hz^{1/2}$ is introduced with silicon nitride drum resonator. With 5-order-of-magnitudes higher sensitivity than the state-of-the-art technique, this study provides a senstive label-free alternative for microsocpy.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, *Exhibit Hall Theater I*

Marriott
Salon I & II

Marriott
Salon III

Marriott
Salon IV

CLEO: QELS-Fundamental Science

FW3M • Ultrafast Spectroscopy in 2D Materials & Heterostructures—Continued

FW3M.5 • 14:15
Nonlinear Interaction of Rydberg Exciton-Polaritons in Two-Dimensional WSe_2, Jie Gu[1,2], Lutz Waldecker[3], Daniel Rhodes[4], Alexandra Boehmke[1], Archana Raja[5], Rian Koots[1], James Hone[4], Tony Heinz[3], Vinod Menon[1,2]; [1]*Dept. of Physics, City College of New York, USA;* [2]*Dept. of Physics, Graduate Center of the City Univ. of New York (CUNY), USA;* [3]*Dept. of Applied Physics, Stanford Univ., USA;* [4]*Dept. of Mechanical Engineering, Columbia Univ., USA;* [5]*Kavli Energy NanoScience Inst., Univ. of California, USA.* We demonstrate the formation of Rydberg exciton-polaritons in monolayer WSe2 embedded in a microcavity and their 10X enhanced nonlinear interaction strength compared to the 1S exciton-polaritons owing to their larger size.

FW3M.6 • 14:30
1D and 2D like Exciton-Exciton Interactions in Atomically Thin Black Phosphorus, Vivek Pareek[1], Bala M. Mariserla[1,2], Andrew Winchester[1], Julien Madéo[1], Keshav M. Dani[1]; [1]*OIST Graduate Univ., Japan;* [2]*School of Physical Sciences, Central Univ. of Karnataka, India.* We study exciton-exciton annihilation in atomically black phosphorus using micro-transient absorption spectroscopy. Our results show a transition from 1D- to 2D-like interactions as we increase the exciton densities.

FW3M.7 • 14:45
Strong Exciton-Coherent Phonon Coupling In Single-Layer MoS_2, Chiara Trovatello[1], Henrique P. C. Miranda[2], Alejandro Molina-Sánchez[4], Rocío Borrego Varillas[1], Luca Moretti[1], Lucia Ganzer[1], Margherita Maiuri[1], Giancarlo Soavi[3], Andrea C. Ferrari[3], Andrea Marini[5], Ludger Wirtz[6], Giulio Cerullo[1,7], Davide Sangalli[5], Stefano Dal Conte[1]; [1]*Politecnico di Milano, Italy;* [2]*Inst. of Condensed Matter and Nanoscience, Universite catholique de Louvain, Belgium;* [3]*Cambridge Graphene Center, Univ. of Cambridge, UK;* [4]*Inst. of Materials Science, Univ. of Valencia, Spain;* [5]*Division of Ultrafast Process in Materials, Area della Ricerca di Roma 1, Italy;* [6]*Universite du Luxembourg, Luxembourg;* [7]*IFN-CNR, Italy.* We use broadband optical pump-probe spectroscopy to study coherent optical phonons in 1L-MoS_2. We detect a strong coupling with the A'_1 mode, which is enhanced around the C-exciton peak. Ab-initio calculations of the phonon-induced band structure variation fully confirm this result.

CLEO: Science & Innovations

SW3N • Cascade Lasers—Continued

SW3N.5 • 14:30
High-power edge-emitting terahertz plasmonic quantum-cascade laser, Yuan Jin[1], Liang Gao[1], John Reno[2], Sushil Kumar[1]; [1]*Lehigh Univ., USA;* [2]*Sandia National Labs, USA.* A scheme to phase-lock multiple terahertz plasmonic microcavities is developed that establishes coherent plasmonic mode traveling in air. Using quantum-cascade gain media, a 3.3THz edge-emitting plasmonic laser with record-high peak output-power of 256mW is demonstrated.

SW3N.6 • 14:45
Controlling the Likelihood of Extreme Pulses in a Quantum Cascade Laser with Optical Feedback and Bias Perturbation, Olivier Spitz[1,2], Jia-Gui Wu[3,4], Mathieu Carras[2], Chee Wei Wong[3], Frederic Grillot[1,5]; [1]*Télécom ParisTech, France;* [2]*mirSense, France;* [3]*Univ. of California Los Angeles, USA;* [4]*Southwest Univ., China;* [5]*Univ. of New Mexico, USA.* We experimentally generate controllable extreme pulses in a mid-infrared quantum cascade laser with external optical injection and square wave perturbation.

SW3O • Long Distance Transmission—Continued

SW3O.6 • 14:30
Impact of Laser Phase Noise on Nonlinear Frequency Division Multiplexing Systems, Francesco Da Ros[1], Simone Gaiarin[1], Darko Zibar[1]; [1]*DTU Fotonik, Denmark.* The impact of Wiener phase noise on NFDM transmission is experimentally investigated for dual-polarization discrete NFDM systems. The results show minimal OSNR penalty in back-to-back and limited degradation for 2000-km transmission for 750-kHz and 100-kHz linewidth, respectively.

SW3O.7 • 14:45
Frequency Modulation Supported Long-haul Transmission Enabled by Nonlinear Equalization with a Low-cost DML, Shaohua Hu[1], Pingping Lei[1], Jing Zhang[1], Yuzhong Feng[1], Xingwen Yi[2], Kun Qiu[1]; [1]*Univ of Electronic Science & Tech China, China;* [2]*Sun Yat-Sen Univ., China.* We experimentally demonstrate an FM-supported 23 Gb/s PAM-4 coherent transmission over 2800 km SSMF utilizing a low-cost DML. The nonlinear equalizers are effective to enable the FM signal recovery.

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, *Exhibit Hall Theater I*

CLEO: Applications & Technology

AW3P • A&T Topical Review on Progress in the Semiconductor Laser Technology II—Continued

AW3P.5 • 14:30 Invited
Development of Terahertz Quantum-Cascade Lasers for Satellite-Borne Measurement of Key Gas Species. Alexander Valavanis[1], Yingjun Han[1], Eleanor Nuttall[1], Esam Zafar[1], Diego Pardo[2], Olivier Auriacombe[2], Thomas Rawlings[2], Nart Daghestani[2], Edmund H. Linfield[1], Brian N. Ellison[2] and A. Giles Davies[2]; [1]*School of Electronic and Electrical Engineering, University of Leeds, UK,* [2]*STFC Rutherford Appleton Laboratory, UK.* We present key developments towards atmospheric chemistry studies using terahertz quantum-cascade lasers (QCLs), including ~1-cm3-scale integration of THz QCLs with waveguides and antennas using precision micromachining, and broadband multimode spectroscopy based on detector-free self-mixing.

AW3Q • A&T Topical Review on Advanced Design, Imaging and Process Technologies for Next Generation Semiconductors II—Continued

15:00–17:00 Coffee Break & Dessert (Exhibit Only Time), *Exhibit Halls 1-3*
Coffee Break Sponsored by COHERENT and THORLABS

15:30–17:00 Product Showcases, *Exhibit Hall Theater I*

Executive Ballroom 210A

Joint

17:00–19:00
JW4A • Sym on Coupling Artificial Atoms to Nano- & Opto-mechanical Systems II
Presider: To Be Announced

JW4A.1 • 17:00 Invited
Phonon networks with SiV centers in diamond waveguides, Peter Rabl[1]; [1]*TU Wien, Austria*. In this talk I will discuss recent theoretical ideas for realizing controlled spin-phonon interactions and scalable phononic quantum networks with silicon-vacancy centers coupled to propagating acoustic modes in diamond waveguides.

JW4A.2 • 17:30 Invited
Creating Quantum States of Sound with Superconducting Qubits, Yiwen Chu[2,1]; [1]*Yale Univ., USA;* [2]*Physics, ETH Zurich, Switzerland*. I will describe our recent experiments involving a high frequency bulk acoustic wave resonator strongly coupled to a superconducting qubit. We use this device to demonstrate quantum operations on the system, including the creation and measurement of quantum mechanical states such as phonon Fock states.

JW4A.3 • 18:00 Invited
Quantum Control of Spins in Silicon Carbide with Photons and Phonons, David Awschalom[1]; [1]*Univ. of Chicago, USA*. Isolated spins in silicon carbide are optically probed, revealing long spin coherence times and high-fidelity quantum control. Gaussian surface acoustic wave resonators mechanically drive coherent Rabi oscillations using phonons that are imaged with focused x-rays.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

17:00–19:00
FW4B • Nanoscale Nonlinear Optics
Presider: To Be Announced

FW4B.1 • 17:00
A Hybrid Dielectric-Semiconductor Resonant Nanostructure for Broadband and Efficient Second-Harmonic Generation, Raktim Sarma[1], Domenico de Ceglia[2], Nishant Nookala[3], Maria Antonietta Vincenti[4], Salvatore Campione[1], Omri Wolf[1], Michael Scalora[5], Mikhail A. Belkin[3], Igal Brener[1]; [1]*Sandia National Labs, USA;* [2]*Univ. of Padova, Italy;* [3]*Univ. of Texas at Austin, USA;* [4]*Univ. of Brescia, Italy;* [5]*US Army AMRDEC, USA*. We experimentally demonstrate a novel approach of coupling leaky-mode resonances in dielectric nanostructures to intersubband transitions in semiconductor quantum wells to realize an ultrathin hybrid device with broadband and high second-harmonic generation efficiency.

FW4B.2 • 17:15
Electrically Tunable Dynamic Phase Modulation Enhanced Second Harmonic Generation of Dielectric Metasurfaces, Xuexue Guo[1], Yimin Ding[1], Xingjie Ni[1]; [1]*Pennsylvania State Univ., USA*. Taking advantage of the dynamic phase modulation arisen from the interaction of dc electrical and optical field, we create super-quadratic field dependent second harmonic generation (SHG) with ultra-high ON/OFF ratio of 15000 on a dielectric metasurface.

FW4B.3 • 17:30
Observation of Extraordinary SHG from All-Dielectric Nanoantennas Governed by Bound States in the Continuum, Kirill Koshelev[1,2], Sergey Kruk[1], Jae-Hyuck Choi[3], Elizaveta V. Melik-Gaykazyan[1,4], Daria Smirnova[1,5], Hong-Gyu Park[3], Yuri S. Kivshar[1,2]; [1]*Australian National Univ., Australia;* [2]*Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia;* [3]*Dept. of Physics, South Korea Univ., South Korea (the Republic of);* [4]*Faculty of Physics, Lomonosov Moscow State Univ., Russia;* [5]*Inst. of Applied Physics, Russia*. We observe record-high efficiency of the second-harmonic generation from AlGaAs nanoantennas fabricated on a transparent substrate and pumped with structured light. The engineered nanoantennas exhibit high-quality optical resonances governed by quasi-bound states in the continuum.

FW4B.4 • 18:00
Disorder-Robust Nonlinear Light Generation in Topological Nanostructures, Sergey S. Kruk[1], Alexander Poddubny[1,2], Daria Smirnova[1], Ivan Kravchenko[3], Barry Luther-Davies[1], Yuri S. Kivshar[1]; [1]*Australian National Univ., Australia;* [2]*ITMO Univ., Russia;* [3]*Oak Ridge National Lab, USA*. We observe topologically nontrivial nonlinear edge states of light in zigzag arrays of silicon nanoparticles. We image the edge states via the third-harmonic generation and demonstrate their robustness against disorder and structural perturbations.

Executive Ballroom 210C

Joint

17:00–19:00
JW4C • Professional Development Session I
Presider: To Be Announced

New this year are Professional Development sessions organized by the CLEO Committee Chairs. For details please refer to the Program Update Sheet.

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

17:00–19:00
FW4D • Chirality, PT Symmetry, & Exceptional Points
Presider: To Be Announced

FW4D.1 • 17:00
Chiral Metasurface Optomechanics, Simone Zanotto[1], Alessandro Tredicucci[3,1], Daniel Navarro-Urrios[2], Marco Cecchini[1], Giorgio Biasiol[4], Alessandro Pitanti[1]; *[1]Istituto di Nanoscienze - CNR, Italy; [2]Universitat de Barcelona, Spain; [3]Università di Pisa, Italy; [4]Istituto Officina dei Materiali, Italy.* We report on mechanical action on light polarization, and its back-action effect, in a chiral metasurface. Our thin-film nanostructured semiconductor device may prove of relevance for fast polarization state generation and detection.

FW4D.2 • 17:30
Tunable Orbital Angular Momentum Microring Lasers Using Chiral Exceptional Points, William Hayenga[1], Jinhan Ren[1], Midya Parto[1], Fan Wu[1], Mohammad Hokmabadi[1], Christian Wolff[2], Ramy El-Ganainy[3], N. Mortensen[2,4], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; *[1]Univ. of Central Florida, CREOL, USA; [2]Center for Nano Optics, Univ. of Southern Denmark, Denmark; [3]Dept. of Physics and Henes Center for Quantum Phenomena, Michigan Technological Univ., USA; [4]Danish Inst. for Advanced Study, Univ. of Southern Denmark, Denmark.* A microring laser generating tunable orbital angular momentum states via chiral exceptional points is demonstrated. An incorporated inner S-bend waveguide construct provides an avenue to enforce unidirectional lasing in a predetermined manner.

FW4D.3 • 17:45
Photonic Spin Polarizer Using Phase-Cancellation Metasurface, Amr Shaltout[1], Jorik van de Groep[1], Yifei Wang[1], Mark Brongersma[1]; *[1]Stanford Univ., USA.* Phase-cancellation metasurfaces are introduced to attenuate the transmission of specific optical mode using destructive interference, and used to implement a broadband circular polarizer with extinction ratio of 20 using silicon based dielectric nanostructures.

FW4D.4 • 18:00
Low Loss Propagation in a Metal-clad Waveguide via PT-Symmetry Breaking, Utsav D. Dave[1], Michal Lipson[1]; *[1]Electrical Engineering, Columbia Univ., USA.* We demonstrate passive PT symmetry breaking between the spatial modes within a single SOI waveguide with metal deposited directly on top. By leveraging this effect, we show low propagation loss of < 1 dB for a 100 μm long, 10 μm wide waveguide partially covered with 100 nm thick metal.

Executive Ballroom 210E

CLEO: Science & Innovations

17:00–19:00
SW4E • Ultrafast Pulse Manipulation
Presider: Cristina Hernandez-Gomez; Rutherford Appleton Laboratory, UK

SW4E.1 • 17:00
TW-Peak-Power Post-Compression of 70-mJ pulses from an Yb Amplifier, Guangyu Fan[1], Paolo Carpeggiani[1], Zhensheng Tao[2], Edgar Kaksis[1], Tadas Balciunas[3], Gulio Coccia[1,6], Vincent Cardin[4], François Légaré[4], Bruno E. Schmidt[5], Andrius Baltuska[1]; *[1]Inst. of Photonics, TU Wien, Austria; [2]Dept. of Physics, Fudan Univ., China; [3]Dept. of Applied Physics, Univ. of Geneva, Switzerland; [4]Institut National de la Recherche Scientifique, Canada; [5]few-cycle, Inc, Canada; [6]Dipartimento di Fisica, Politecnico di Milano, Italy.* We present the energy record achievement in single stage, stretched hollow core fiber compression. 1μm, 220fs pulses, are compressed to 25fs, 40mJ with ~60% efficiency.

SW4E.2 • 17:15
Two-Stage Nonlinear Compression of a Yb:KGW Laser Amplifier to Sub-10 fs Duration, John E. Beetar[1], Federico Rivas[1], Shima Gholam Mirzaeimoghadar[1], Yangyang Liu[1], Michael Chini[1,2]; *[1]Univ. of Central Florida, USA; [2]CREOL, The College of Optics and Photonics, USA.* We demonstrate the nonlinear compression of pulses from a commercial Yb:KGW laser amplifier using a two-stage hollow-core fiber and multi plate continuum compressor to below 9 fs duration with an overall system transmission of 60%.

SW4E.3 • 17:30
Optical Thin Film Compression for Laser Induced Plasma Diagnostics, Masruri Masruri[1], Jonathan Wheeler[2,1], Ioan Dancus[1], Riccardo Fabbri[3], Andrei Naziru[1], Radu Secareanu[1], Daniel Ursescu[1], Gabriel Cojocaru[4], Razvan Ungureanu[4], Deano Farinella[5], Moana Pittman[6], Sergey Mironov[7], Septimiu Balascuta[1], Domenico Doria[1], David Ros[6], Razvan Dabu[1]; *[1]ELI-NP, Romania; [2]IZEST, France; [3]European XFEL GmbH, Germany; [4]CETAL-PW (INFLPR), Romania; [5]Univ. of California at Irvine (UCI), USA; [6]LASERIX (UPSud - LUMAT), France; [7]Federal Research Center Inst. of Applied Physics of the Russian Academy of Science (IAP RAS), Russia.* Zeonor thin film compressor based on self-phase modulation is presented as an ultrashort probe for a plasma diagnostics at ELI-NP. The capability of a compression factor more than two enables a probe of 10 fs.

SW4E.4 • 17:45
Relative-Phase Synchronization in a Sub-Cycle Parametric Waveform Synthesizer, Roland E. Mainz[1,2], Giulio Maria Rossi[1,2], Fabian Scheiba[1,2], Yudong Yang[1,2], Giovanni Cirmi[1,2], Franz Kärtner[1,2]; *[1]Center for Free-Electron Laser Science, Germany; [2]Physics Dept. and the Hamburg Centre for Ultrafast Imaging, Germany.* We compare two different methods for relative phase synchronization among two channels of a parallel parametric waveform synthesizer. The achieved stability allows for reproducible high-energy sub-cycle pulses capable to generate isolated attosecond pulses without gating.

SW4E.5 • 18:00
Phase-Locked Programmable Femtosecond Pulse Bursts from a Regenerative Amplifier, Tobias Flöry[1], Edgar Kaksis[1], Audrius Pugzlys[1,2], Andrius Baltuska[1,2], Gergö Krizsán[3,4], Gyula Polónyi[3,4], József Fülöp[3,4]; *[1]Photonik Institut, TU Wien, Austria; [2]Center for Physical Sciences & Technology, Lithuania; [3]Inst. of Physics, Univ. of Pécs, Hungary; [4]ELI ALPS, Hungary.* We demonstrate phase-controlled pulse-burst amplification based on differential pathlength stabilization between the master oscillator and the amplifier cavities. This technique boosts the safe level of extractable burst energy and suppresses fluctuations in various burst-mode applications.

Executive Ballroom 210F

17:00–19:00
SW4F • Terahertz Sources & Communication
Presider: Dam Mittleman, Brown Univ., USA

SW4F.1 • 17:00
Optimization and fabrication of two-quantum well THz QCLs operating above 200 K, Martin C. Franckie[1], Lorenzo Bosco[1], Mattias Beck[1], Elena Mavrona[1], Jérôme Faist[1]; *[1]ETH Zürich, Switzerland.* We present the first THz quantum cascade laser operating above 200 K. The design is based on two quantum wells per period and was optimized using a non-equilibrium Green's function model.

SW4F.2 • 17:15
Heterogeneous THz quantum cascade lasers: Gain recovery dynamics study, Christian G. Derntl[1], Giacomo Scalari[2], Mattias Beck[2], Jerome Faist[2], Karl Unterrainer[1], Juraj Darmo[1]; *[1]TU Wien, Austria; [2]ETH Zürich, Switzerland.* We present our investigations of the interactions between the individual stacks of a heterogeneous terahertz quantum cascade laser by measuring their gain recovery time with terahertz pump / terahertz probe time domain spectroscopy.

SW4F.3 • 17:30
20 GHz Continuous Electrical Tuning of a High-power Terahertz Distributed-feedback Laser, Liang Gao[1], Yuan Jin[1], John Reno[2], Sushil Kumar[1]; *[1]Lehigh Univ., USA; [2]Sandia National Labs, USA.* Large electrical tuning of 20GHz is demonstrated for a 3.3THz distributed-feedback quantum-cascade laser at 56K. A new scheme with phase-locked plasmonic microcavities realizes order-of-magnitude greater output-power and significantly improved far-field beam compared to previous results.

SW4F.4 • 17:45
Full W-band Frequency Measurement of THz Waves by Electro-Optic Sampling Using Modulator-Based Optical Comb Source, Isao Morohashi[1], Norihiko Sekine[1], Akifumi Kasamatsu[1], Iwao Hosako[1]; *[1]National Inst of Information & Comm Tech, Japan.* We have demonstrated THz frequency measurement in the full W-band by optical heterodyne using optical combs. Full W-band signals were measured by sweeping the comb spacing on the range from 9 to 10.2 GHz.

SW4F.5 • 18:00 Invited
Coherent THz Pulse Generation and Radiation Based on a Fully-Electronic Digital-to-Impulse Technique Implemented in Silicon, Aydin Babakhani[1]; *[1]ECE, UCLA, USA.* In this work, we present the technique of THz pulse generation and radiation based on a laser-free fully-electronic solution implemented in a 130nm SiGe technology. The silicon chip radiates a frequency comb with programmable comb spacing. The chip covers the entire frequency range from 30GHz to 1.1THz with frequency resolution of 2Hz.

Executive Ballroom 210G | **Executive Ballroom 210H** | **Meeting Room 211 A/B**

CLEO: Science & Innovations

17:00–19:00
SW4G • Optical Frequency Synthesis & Microwave Generation
Presider: Franklyn Quinlan; NIST, USA

SW4G.1 • 17:00
Optically Generated 10-GHz Signal with 10 Microradian Residual Phase Instability, Takuma Nakamura[1], Josue Davila-Rodriguez[1], Holly Leopardi[2], Jeff A. Sherman[1], Tara M. Fortier[1,2], Xiaojun Xie[3], Joe C. Campbell[3], Scott A. Diddams[1,2], Franklyn Quinlan[1,2]; *[1]Time and Frequency Division, National Inst. of Standards and Tech, USA; [2]Dept. of Physics, Univ. of Colorado Boulder, USA; [3]Dept. of Electrical and Computer Engineering, Univ. of Virginia, USA.* We demonstrate ultra-stable 10-GHz generation based on single-fiber-branch Er:fiber combs. Residual rms phase fluctuations were 10 microradians at 10 s, with corresponding fractional frequency instability of 5×10^{-17} at 1 s and 1×10^{-18} at 200 s.

SW4G.2 • 17:30
Ultra-low noise microwave generation using carrier-envelope-offset signal of 25-GHz EOM comb, Atsushi Ishizawa[1], Tadashi Nishikawa[2], Kenichi Hitachi[1], Kazutaka Hara[1,2], Kenya Hitomi[1,2], Tomoya Akatsuka[1], Tetsuomi Sogawa[1], Hideki Gotoh[1]; *[1]NTT Basic Research Labs, Japan; [2]Tokyo Denki Univ., Japan.* Using carrier-envelope-offset signal of a 25-GHz electro-optics-modulation comb, we demonstrated a record phase-noise reduction of a conventional signal generator and an unprecedented measurement of the absolute optical frequency at 12-order-of-magnitude accuracy without any optical reference.

SW4G.3 • 17:45
Free-running Monolothic Laser-based 8-GHz Photonic Microwave Generation, Manoj P. Kalubovilage[2], Mamoru Endo[2], Thomas R. Schibli[2,1]; *[1]JILA, USA; [2]Physics, Univ. of Colorado Boulder, USA.* An ultra-low noise 8-GHz microwave carrier was generated with a free-running monolithic mode-locked laser. The measured phase noise reached below -163 dBc/Hz at 10 kHz and -178 dBc/Hz at 100 kHz offsets.

SW4G.4 • 18:00
Phase locking of a tunable OEO to an optical frequency comb for microwave synthesis from an optical reference, Antoine Rolland[1], Naoya Kuse[1], Martin E. Fermann[1]; *[1]IMRA, USA.* We phase lock a tunable OEO to an optically referenced stepped precision microwave reference provided with a fiber comb from intermodal beating, overcoming the common stability limits of direct digital synthesis in tunable microwave generation.

17:00–19:00
SW4H • Supercontinuum Generation
Presider: Jaime Cardenas; Univ. of Rochester, USA

SW4H.1 • 17:00
Polarization effects in silicon-nitride waveguides: Supercontinuum, carrier-envelope offset, and optical beatnotes, Lingfang Wang[1,2], Hongquan Li[1], David Carlson[3], Scott B. Papp[3], Leo Hollberg[1]; *[1]HEPL & Dept. of Physics, Stanford Univ., USA; [2]School of Optoelectronic Science and Engineering, Univ. of Electronic Science and Technology of China, China; [3]Time and Frequency Division, National Inst. of Standards and Technology, USA.* Polarization dependence of second/third-harmonic and supercontinuum generation in silicon-nitride waveguides is mapped from 350-1750 nm. We identify parameters suited for generating coherent signals near 500 and 1000 nm for optical clocks, f_{CEO} and beatnote detection.

SW4H.2 • 17:15
Few-cycle pulses and ultraflat supercontinuum with silicon-nitride waveguides, David R. Carlson[1], Phillips Hutchison[1], Daniel Hickstein[1], Scott B. Papp[1]; *[1]NIST, USA.* We experimentally and numerically demonstrate few-cycle pulse generation in chip-integrated waveguides made from silicon nitride. When these pulses seed supercontinuum generation in two-section waveguides, coherent ultraflat spectra spanning more than an octave can be realized.

SW4H.3 • 17:30 Invited
Coherent Supercontinuum Generation in a Silicon Nitride Chip, Yoshitomo Okawachi[1]; *[1]Columbia Univ., USA.* Advances in CMOS-compatible silicon technology offers a path towards chip-scale nonlinear photonic devices. I will discuss our recent work on on-chip supercontinuum generation in silicon-nitride waveguides for applications including spectroscopy, frequency metrology, and optical clocks.

SW4H.4 • 18:00
Lotus-like dual soliton generation and phase shifting in an 88 GHz high-order-mode-suppressed Si_3N_4 microring, Hao Liu[1], Jinghui Yang[1], Shu-Wei Huang[2], Mingbin Yu[3], Dim Lee Kwong[3], Chee Wei Wong[1]; *[1]Univ. of California Los Angeles, USA; [2]Dept. of Electrical, Computer, and Energy Engineering,, Univ. of Colorado Boulder, USA; [3]Inst. of Microelectronics, A*STAR, Singapore.* Here we report a unique lotus-like dual dissipative soliton spectrum generated in an 88 GHz tapered Si_3N_4 microring. The mode-locking nature is verified by both amplitude noise and FROG measurement. A continuous phase shifting of such state is successfully observed directly in frequency domain.

CLEO: Applications & Technology

17:00–19:00
AW4I • Medical Devices & Systems
Presider: David Nolte; Animated Dynamic Inc, USA

AW4I.1 • 17:00 Invited
OCT with Multi-MHz Swept Lasers, Thomas Klein[1]; *[1]Optores GmbH, Germany.* Recent developments in commercially available wavelength-swept lasers enable optical coherence tomography (OCT) in the multi-MHz range. These unpreceded speeds benefit a wide range of applications, including microangiography, industrial inspection, large-area surveys and OCT-guided surgery.

AW4I.2 • 17:30
Integrated Parylene Photonic Waveguides with Embedded Micromirrors for Light Delivery and Manipulation Deep into Tissue, Jay W. Reddy[1], Maya Lassiter[1], Ramgopal Venkateswaran[1], Maysamreza Chamanzar[1]; *[1]Electrical and Computer Engineering, Carnegie Mellon Univ., USA.* We demonstrate flexible photonic waveguides realized in a biocompatible PDMS/Parylene C platform with broadband out-of-plane input/output coupling. The waveguides are packaged with laser diodes to realize a compact, fully functional photonic device for in-vivo applications.

AW4I.3 • 17:45
Label-free human brain and skin imaging enabled by Er:fiber-laser-based tunable ultrafast sources, Hsiang-Yu Chung[1,2], Rüdiger Greinert[3], Markus Glatzel[4], Franz Kärtner[1,2], Guoqing Chang[5]; *[1]Center for Free-Electron Laser Science, DESY, Germany; [2]Physics, Universität Hamburg, Germany; [3]Skin Cancer Center Buxtehude, Germany; [4]Inst. of Neuropathology, Univ. Medical Center Hamburg-Ependorf, Germany; [5]Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China.* We demonstrate label-free multiphoton microscopy of human brain and skin tissues with an Er:fiber-laser-based ultrafast source that emits femtosecond pulses at 775 nm and 1250 nm.

Meeting Room 211 C/D

CLEO: Science & Innovations

17:00–19:00
SW4J • Design & Simulation of Micro- & Nano-photonic Devices
Presider: Joyce Poon; University of Toronto, Canada

SW4J.1 • 17:00
Nanocavity based on a topological corner state in a two-dimensional photonic crystal, Yasutomo Ota[1], Ryota Katsumi[2], Katsuyuki Watanabe[1], Feng Liu[3], Katsunori Wakabayashi[3,4], Satoshi Iwamoto[1,2], Yasuhiko Arakawa[1]; [1]*Nanoquine, The Univ. of Tokyo, Japan;* [2]*IIS, The Univ. of Tokyo, Japan;* [3]*Kwansei Gakuin Univ., Japan;* [4]*National Inst. for Material Science, Japan.* We demonstrate a photonic crystal nanocavity based on a topological corner state. The design exploits the hierarchical bulk-edge-corner correspondence for the two-dimensional photonic crystal, opening a deterministic route to introduce nanocavities in topological photonics platforms.

SW4J.2 • 17:15
Bloch-Floquet Waves in Optical Ring Resonators, Kathleen McGarvey-Lechable[1], Pablo Bianucci[1]; [1]*Concordia Univ., Canada.* We develop a general theory of the modal coupling of degenerate resonances in optical ring resonators based on Bloch-Floquet theory. This theory can predict the splitting associated with this coupling in all the ring resonances.

SW4J.3 • 17:30
Inverse designed Fano resonance in Silicon microresonators, Kiyoul Yang[1], Jinhie Skarda[1], Michele Cotrufo[2], Geun Ho Ahn[1], Andrea Alu[2], Jelena Vuckovic[1]; [1]*Stanford Univ., USA;* [2]*Univ. of Texas at Austin, USA.* We demonstrate, for standard silicon resonators, that a Fano lineshape can be created in the response function by placing an inverse-designed reflector into the side-coupled waveguide. Inverse design allows for control of the Fano spectrum and small device footprint, with applications in photonics.

SW4J.4 • 17:45
An On-chip Full Poincaré Beam Emitter Based on an Optical Micro-ring Cavity, Wenbo Lin[1], Yasutomo Ota[2], Yasuhiko Arakawa[2], Satoshi Iwamoto[1,2]; [1]*Inst. of Industrial Science, The Univ. of Tokyo, Japan;* [2]*Inst. of Nano Quantum Information Electronics, The Univ. of Tokyo, Japan.* We numerically demonstrate an on-chip full Poincaré beam emitter. We employ a micro-ring resonator augmented with scatterer arrays, which synthesizes the Poincaré beam as a superposition of twisted beams carrying different orbital- and spin-angular momenta.

SW4J.5 • 18:00
Adjoint-based optimization of active nanophotonic devices, Jiahui Wang[1], Yu Shi[1], Tyler Hughes[1], Zhexin Zhao[1], Shanhui Fan[1]; [1]*Stanford, USA.* We combine the adjoint variable method and the multi-frequency finite-difference frequency-domain method for systematic optimization of active nanophotonic devices. As an example, we numerically optimized a dynamic isolator which remains high isolation performance with half the modulation length.

Meeting Room 212 A/B

CLEO: Applications & Technology

17:00–19:00
AW4K • Lidar
Presider: Fabio Di Teodoro; Raytheon SAS, USA

AW4K.1 • 17:00 Invited
Imaging through Flames with Coherent Laser Ranging, Esther Baumann[1], Eric W. Mitchell[1], Matthew S. Hoehler[1], Fabrizio R. Giorgetta[1], Torrey Hayden[2], Gregory B. Rieker[2], Nathan R. Newbury[1]; [1]*NIST, USA;* [2]*Univ. of Colorado, USA.* We show that coherent laser detection and ranging can see through flames and capture 3D images of a deforming object. A ranging precision of 30 µm through acetylene flame at a 2-meter stand-off is achieved.

AW4K.2 • 17:30
Absolute Distance Measurement with Large Non-ambiguous Range by an Electro-optic Triple-comb, Xianyu Zhao[1], Qu Xinghua[1], Fumin Zhang[1]; [1]*Tianjin Univ., China.* We present a multi-heterodyne interferometry for long distance measurement. The synthetic wavelengths chain can be established through triple-comb with cascaded phase modulators. The experimental results demonstrated a relative ranging precision of about 7×10^{-7}.

AW4K.3 • 17:45
Frequency-modulated continuous-wave lidar using a phase-diversity coherent optical receiver for simultaneous ranging and velocimetry, Hongxiang Zhang[1], Kai Chen[1], Xu Zhongyang[1], Shilong Pan[1], Dan Zhu[1]; [1]*Nanjing Univ. of Aeronautics and As, China.* Conventional FMCW lidar has ambiguous ranging and velocimetry if de-chirped frequency related to distance is close to Doppler frequency shift related to velocity, which is avoided in this work using a phase-diversity coherent optical receiver.

AW4K.4 • 18:00
A Basic Approach for Speed Profiling of Alternating Targets with Photonic Doppler Velocimetry, Mustafa M. Bayer[1], Rasul Torun[1], Imam Uz Zaman[1], Ozdal Boyraz[1]; [1]*Univ. of California Irvine, USA.* Single tone continuous wave lidar system is utilized to construct the speed profile of an oscillating membrane by applying photonic Doppler velocimetry with amplitude-modulated light. Then short-time Fourier Transform is applied to acquire the profile.

Meeting Room 212 C/D

CLEO: Science & Innovations

17:00–19:00
SW4L • Optical Detection of Vapors or Hazardous Environments
Persider: Erik Emmons; Edgewood Chemical Biological Center, USA

SW4L.1 • 17:00
Dual-comb laser system for time-resolved studies of fireballs in the MIR, Ryan T. Rhoades[1], Caroline Lecaplain[1], Peter G. Schunemann[2], R. J. Jones[1]; [1]*College of Optical Sciences, Univeristy of Arizona, USA;* [2]*BAE Systems, USA.* We present a high power all-fiber dual-comb system suitable for time-resolved spectroscopy measurements in the mid-infrared to study explosion dynamics and detection of chemical species.

SW4L.2 • 17:15
Broadband Infrared Laser Absorption Spectroscopy of High-explosive Detonations, Mark C. Phillips[1], Brian Brumfield[1], Bruce E. Bernacki[1], Sivanandan S. Harilal[1], Joel M. Schwallier[2], Nick Glumac[2]; [1]*Pacific Northwest National Lab, USA;* [2]*Mechanical Science & Engineering, Univ. of Illinois at Urbana-Champaign, USA.* We measure time-resolved absorption spectra in high-explosive detonations using an external cavity quantum cascade laser swept over the range 2050-2300 cm^{-1}. Absorption from CO, CO_2, H_2O, N_2O, and particulates is characterized.

SW4L.3 • 17:30
Detection of isotopic shifts and hyperfine structures of uranium transitions using LIF of laser ablation plumes, Sivanandan S. Harilal[1], Bruce E. Bernacki[1], Mark C. Phillips[1]; [1]*Pacific Northwest National Lab, USA.* We report isotopic shifts and hyperfine structures of selected U transitions employing tunable laser-induced fluorescence spectroscopy of laser ablation plumes.

SW4L.4 • 17:45
Standoff Detection of Uranyl Fluoride Using Ultrafast Laser Filamentation-induced Fluorescence, Patrick J. Skrodzki[1], Milos Burger[1], Lauren A. Finney[1], Frederic Poineau[2], Samundeeswari M. Balasekaran[2], Ken R. Czerwinski[2], Igor Jovanovic[1]; [1]*Univ. of Michigan, Ann Arbor, USA;* [2]*Univ. of Nevada Las Vegas, USA.* We demonstrate that femtosecond laser filamentation combined with time-resolved laser-induced fluorescence spectroscopy is viable for remote detection of uranyl fluoride, a powerful indicator of uranium enrichment activity.

SW4L.5 • 18:00
Hydrodynamics and Spatio-temporal Mapping of Oxide Formation in Laser-produced U Plasmas, Patrick J. Skrodzki[1], Milos Burger[1], Igor Jovanovic[1], Mark C. Phillips[2], Sivanandan S. Harilal[2]; [1]*Univ. of Michigan, Ann Arbor, USA;* [2]*Pacific Northwest National Lab, USA.* We combine optical emission spectroscopy with hydrodynamic measurements in laser-produced uranium plasma in air to detect formation of higher uranium oxide states. Generation of uranium oxides reduces the excited atomic uranium population.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

17:00–19:00
FW4M • Advanced Techniques & Applications in Ultrafast Spectroscopy
Presider: Daniele Brida, University of Luxembourg, Luxembourg

FW4M.1 • 17:00 Invited
Imaging the Motion of Charge with Time-Resolved Photoemission Electron Microscopy, Keshav M. Dani[1]; [1]*Okinawa Inst of Science & Technology, Japan.* Combining photoemission electron microscopy with ultrafast pump-probe techniques, we make nanometer/femtosecond scale movies of photocarrier dynamics in semiconductor structures. Our movies capture the evolving, spatially-inhomogenous photocarrier distribution in van der Waals heterostructures. They reveal new insights into photocarrier trapping at the nanoscale in perovskite photovoltaic films, and in charge-separation processes occurring at the surface of doped semiconductors.

FW4M.2 • 17:30
Time- and Angle-Resolved Photoemission Spectroscopy using an Ultrafast XUV Source at 21.8 eV, Yangyang Liu[1], John E. Beetar[1], Md M. Hosen[1], Gyanendra Dhakal[1], Christopher Sims[1], Marc Etienne[1], Firoza Kabir[1], Klauss Dimitri[1], Sabin Regmi[1], Madhab Neupane[1], Michael Chini[1]; [1]*Univ. of Central Florida, USA.* We demonstrate a novel trARPES setup using high-order harmonic probe pulses produced from a moderately high power Yb: KGW amplifier. The surface band structure of Zr_2Te_2P is measured using a single harmonic at 21.8 eV.

FW4M.3 • 17:45
Laser cooling of semiconductors traced in the time domain, Jan F. Lippmann[1], Alfred Leitenstorfer[1], Denis Seletskiy[2,1]; [1]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany;* [2]*Dept. of Engineering Physics, Polytechnique Montréal, Canada.* Despite tremendous progress in optical refrigeration of rare-earth-doped crystals, laser cooling in III-V semiconductors has not been demonstrated to date. Here we report first observation of cooling in GaAs/InGaP double heterostructures on a sub-nanosecond timescale.

FW4M.4 • 18:00
Ultrafast Magnetic Microscopy using High-Harmonic Radiation, Sergey Zayko[1], Ofer Kfir[1], Michael Heigl[2], Michael Lohmann[1], Murat Sivis[1], Manfred Albrecht[2], Claus Ropers[1,3]; [1]*Univ. of Göttingen, Germany;* [2]*Experimentalphysik IV, Institut für Physik, Germany;* [3]*International Center for Advanced Studies of Energy Conversion (ICASEC), Univ. of Göttingen, Germany.* We report ultrafast nanoscale magnetic microscopy using high-harmonic radiation, reaching 19 nm spatial resolution. The femtosecond-scale demagnetization of worm-like magnetic domains in Co/Pd multilayers is quantitatively mapped with 50-fs temporal resolution.

Marriott
Salon III

CLEO: Science & Innovations

17:00–19:00
SW4N • High Power & Narrow Linewidth Lasers
Presider: James Gupta, National Research Council of Canada, Canada

SW4N.1 • 17:00
Supersymmetric Laser Arrays, Mohammad Parvinnezhad Hokmabadi[1], Nicholas Nye[1], Ramy El-Ganainy[2], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*Univ. of Central Flordia, USA;* [2]*Physics, Michigan Technological Univ., USA.* By harnessing notions from supersymmetry, we experimentally demonstrate a supersymmetric laser array that is capable of emitting exclusively in its fundamental transverse mode with a large radiance.

SW4N.2 • 17:15
Continuous Wave Green Lasing at Room Temperature in Two-Dimensional Photonic Crystal Perovskite Laser, Jiyoung Moon[1], Masoud Alahbakhshi[1], Abouzar Gharajeh[1], Ross Haroldson[1], Roberta Hawkins[1], Zhitong Li[1], Walter Hu[1,2], Anvar Zakhidov[1,3], Qing Gu[1]; [1]*The Univ. of Texas at Dallas, USA;* [2]*Fudan Univ., China;* [3]*ITMO Univ., Russia.* Direct patterning of methylammonium lead bromide ($MAPbBr_3$) perovskite enabled green lasing in two-dimensional photonic crystal on the Si platform, under continuous wave pumping at room temperature for the first time.

SW4N.3 • 17:30 Invited
High-Power and High-Beam-Quality Photonic-Crystal Lasers, Susumu Noda[1]; [1]*Kyoto Univ., Japan.* Recent progress in photonic crystal lasers is described. 10W-class high-power and high-beam quality (M^2=2) operation is successfully demonstrated using InGaAs/GaAs semiconductor systems. The extension to InGaN/GaN semiconductor ystems is also discussed.

SW4N.4 • 18:00
Over 2W Room Temperature Lasing On a Large Area Photonic Crystal Quantum Cascade Laser, Zhixin Wang[1], Yong Liang[1], Bo Meng[1], Yanting Sun[2], Giriprasanth Omanakuttan[2], Emilio Gini[3], Mattias Beck[1], Ilia Sergachev[4], Sebastian Lourdudoss[4], Jérôme Faist[1], Giacomo Scalari[1]; [1]*Inst. for Quantum Electronics, ETH Zürich, Switzerland;* [2]*KTH, Sweden;* [3]*FIRST Lab ETH Zürich, Switzerland;* [4]*Wyss Zürich, Switzerland.* We present a large-area (1.5 mm × 1.5 mm) photonic crystal quantum cascade laser, with over 2 W peak power at room temperature (289 K), and symmetrical, narrow (< 1°), single-lobed surface-emitting beam.

Marriott
Salon IV

17:00–19:00
SW4O • Short-Reach Communication Technologies
Presider: David Geisle; MIT Lincoln Laboratory, USA

SW4O.1 • 17:00
Experimental Demonstration of a Sparse-FFT Based Quick Synchronization Method for FBMC/OQAM Systems, Yating Xiang[1], Ming Tang[1], Xi Chen[1], Qiong Wu[1], Huibin Zhou[1], Songnian Fu[1], Deming Liu[1]; [1]*Huazhong Univ. of Sci.&Tech., China.* A quick and accurate synchronization algorithm based on the sparse-FFT is proposed for FBMC/OQAM systems with experimental verification of 50km SSMF transmission. The computation complexity is greatly reduced to 6.7% of the conventional correlation-based method.

SW4O.2 • 17:15
50-Gb/s Dispersion-unmanaged DMT Transmission with Injection Locked 10G-class 1.55-μm DML, Lei Xue[1,3], Lilin Yi[3], Lu Zhang[2,3], Oskars Ozolins[4,2], Aleksejs Udalcovs[4], Xiaodan Pang[4,5], Jiajia Chen[2]; [1]*Chalmers Univ. of Technology, Sweden;* [2]*KTH Royal Inst. of Technology, Sweden;* [3]*State Key Lab of Advanced Optical Communication System and Networks, Shanghai Jiao Tong Univ., China;* [4]*Networking and Transmission Lab, RISE Acreo AB, Sweden;* [5]*Infinera, Sweden.* We demonstrate 50-Gb/s DMT signal transmission over 20-km SMF by using a 10G-class 1.55-μm DML without optical dispersion compensation. Injection locking technique is introduced, which doubles system bandwidth and greatly suppresses DML chirp.

SW4O.3 • 17:30
Variable-step DD-FTN Algorithm for PAM8-based Short-reach Optical Interconnects, Haide Wang[1], Ji Zhou[1], Fan Li[2], Long Liu[1], Changyuan Yu[3], Xingwen Yi[2], Xincheng Huang[1], Weiping Liu[1], Zhaohui Li[2]; [1]*Dept. of Electronic Engineering, Jinan Univ., China;* [2]*Sun Yat-sen Univ., China;* [3]*The Hong Kong Polytechnic Univ., Hong Kong.* We experimentally demonstrate a variable-step DD-FTN algorithm for 129-Gbit/s PAM8-based short-reach optical interconnects. The fast and stable convergence of the proposed algorithm leads to better performance than conventional DD-FTN algorithm.

SW4O.4 • 17:45
Joint Blind Equalization of CD and RSOP Using Kalman Filter in Stokes Vector Direct Detection System, Nan Cui[1], Zibo Zheng[1], Xiaoguang Zhang[1], Wei Yi[1], Ruipu Guo[1], Wenbo Zhang[1], Lixia Xi[1], Xianfeng Tang[1]; [1]*Beijing Univ. of Posts and Telecomm, China.* We propose a joint blind equalization for CD and RSOP in SV-DD system based on new Kalman structure, which has strong tolerance to CD (more than 2550 ps/nm) combined with ultra-fast RSOP (up to 2Mrad/s).

SW4O.5 • 18:00 Invited
Programmable VCSEL-based Transceivers for Multi-terabit Capacity Networking, Michela Svaluto Moreolo[1], Laia Nadal[1], Josep M. Fabrega[1], Ricardo Martínez[1], Ramon Casellas[1]; [1]*Ctr Tecnològic de Telecom de Catalunya, Spain.* Photonic transceivers adopting large-bandwidth vertical cavity surface emitting lasers (VCSELs) at long-wavelength, coherent detection and adaptive digital signal processing are presented as promising programmable architectures to provide multi-terabit capacity in future software-defined optical metro networks.

NOTES

Executive Ballroom 210A

Joint

JW4A • Sym on Coupling Artificial Atoms to Nano- & Opto-mechanical Systems II—Continued

JW4A.4 • 18:30
Quantum Acoustics with Lithium Niobate Nanocavities, Patricio Arrangoiz-Arriola[1], E. Alex Wollack[1], Marek Pechal[1], Wentao Jiang[1], Zhaoyou Wang[1], Timothy McKenna[1], Amir Safavi-Naeini[1]; [1]*Stanford Univ., USA.* We couple a superconducting qubit to a piezoelectric nanomechanical resonator fabricated from thin film lithium niobate (LN). The sizeable piezoelectric coefficient of LN leads to a coupling rate $g/2\pi > 15$ MHz allowing quantum operations.

JW4A.5 • 18:45
Scalable Phononic Quantum Networks of Spins in Diamond, Mark C. Kuzyk[1]; [1]*Univ. of Oregon, USA.* Phononic quantum networks with alternating phononic crystal waveguides have been developed. This new architecture solves the inherent scalability problem in coupling spins withmechanical vibrations by breaking large networks into small and closed mechanical subsystems.

Executive Ballroom 210B

CLEO: QELS-Fundamental Science

FW4B • Nanoscale Nonlinear Optics—Continued

FW4B.5 • 18:15
Resonance Splitting and Enhanced Optical Nonlinearities in ITO-based Epsilon-near-zero Metasurface with Cross-shaped Nanoantennas, Cong Liu[1], Kai Pang[1], Karapet Manukyan[1], Orad Reshef[2], Yiyu Zhou[3], Joel Patrow[1], Anuj Pennathur[1], Hao Song[1], Zhe Zhao[1], Runzhou Zhang[1], Fatemeh Alishahi[1], Ahmad Fallahpour[1], Yinwen Cao[1], Ahmed Almaiman[1], Jahan Dawlaty[1], N. Apurv Chaitanya[5], Israel De Leon[5], Zahirul Alam[2], Robert Boyd[2,3], Moshe Tur[4], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*Univ. of Ottawa, Canada;* [3]*Univ. of Rochester, USA;* [4]*Tel Aviv Univ., Israel;* [5]*Tecnológico de Monterre, Mexico.* We experimentally demonstrate a strong-coupling-induced resonance splitting in indium-tin-oxide (ITO) based epsilon-near-zero (ENZ) metasurface with cross-shaped nanoantennas. An ~11-nm blue shift of the carrier wavelength is observed for this metasurface under ~4-GW/cm^2 peak-power density.

FW4B.6 • 18:30
Nonlinear and electro-optical properties of epsilon near zero materials: are they all they are believed to be?, Jacob Khurgin[1], Hua-Zhou Chen[2], Ren-Min Ma[2]; [1]*Johns Hopkins Univ. , USA;* [2]*School of Physics, Peking Univ., China.* Nonlinear and Electro-optical properties of Epsilon-near-zero (ENZ) materials and Epsilon-and-mu-near-zero (EMNZ) materials have been investigated. The ENZ enhancement was shown to be a slow light effect and EMNZ enhancement was found to be nonexistent.

FW4B.7 • 18:45
Vertical emission of second and third harmonic light from GaAs nanowires below the band edge, Michael Scalora[1], Jose Trull[2], Crina Cojocaru[2], Maria Antonietta Vincenti[3], Luca Carletti[5], Domenico de Ceglia[5], Costantino De Angelis[3,4]; [1]*US Army Aviation and Missile Command, USA;* [2]*Physics Dept., Universitat Politècnica de Catalunya, Spain;* [3]*Dept. of Information Engineering, Univ. of Brescia, Italy;* [4]*National Inst. of Optics (INO-CNR), Italy;* [5]*Dept. of Information Engineering, Univ. of Padova, Italy.* Using a hydrodynamic approach we predict bulk- and surface-induced second and third harmonic generation from a GaAs nanowire grating. Absorption is inhibited below the band-edge and conversion efficiencies are predicted to be 0.5% at 333nm.

Executive Ballroom 210C

Joint

JW4C • Professional Development Session I—Continued

New this year are Professional Development sessions organized by the CLEO Committee Chairs. For details please refer to the Program Update Sheet.

19:00–20:30 Conference Reception, *Grand Ballroom 220B/C*

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FW4D • Chirality, PT Symmetry, & Exceptional Points—Continued

FW4D.5 • 18:15
Coherent Virtual Absorption and Embedded Eigenstates in non-Hermitian PT-Symmetrical Systems, Aleksandr Krasnok[1], Zarko Sakotic[1], Andrea Alu[1]; [1]*CUNY Advanced Science Research Center, USA.* In this work, we demonstrate how the concept of coherent excitation can pave the way to light scattering control in an extreme fashion in non-Hermitian PT-symmetrical systems supporting an embedded eigenstate.

FW4D.6 • 18:30
Robust Exceptional Points, Hamidreza Ramezani[1], Cem Yuce[2]; [1]*Univ. of Texas,Rio Grande Valley, USA;* [2]*Dept. of Physics, Eskisehir Technical Univ., Turkey.* We construct a theory to introduce the concept of robust exceptional points against disorder in photonics. Our proposal will advance the concept of topological localized states to an unexplored area of topological extended (bulk) states.

FW4D.7 • 18:45
Extreme All-dielectric Huygens' Metasurfaces based on Quasi-bound States in the Continuum, Mingkai Liu[1], Dukyong Choi[1,2]; [1]*Australian National Univ., Australia;* [2]*Jinan Univ., China.* We introduce and experimentally demonstrate a novel platform to connect the concepts of Huygens' condition and bound states in the continuum, allowing Huygens' metasurfaces with controllable Q-factors over orders of magnitude.

Executive Ballroom 210E

CLEO: Science & Innovations

SW4E • Ultrafast Pulse Manipulation—Continued

SW4E.6 • 18:15
Programmable Control of Femtosecond Structured Light, Randy A. Lemons[1,2], Wei Liu[2], Charles G. Durfee[1], Josef C. Frisch[2], Steve Smith[2], Joseph Robinson[2], Alan Fry[2], Sergio Carbajo[2]; [1]*Colorado School of Mines, USA;* [2]*SLAC National Accelerator Lab, USA.* We present a laser architecture with programmable control of the polarization vector, transverse and longitudinal intensity, and wavefront in the near and far field as a novel tool to probe and control matter.

SW4E.7 • 18:30
Precision control of intense cycle-sculpted electric fields by fully stabilized three-channel optical waveform synthesizer, Bing Xue[1], Yuuki Tamaru[1,2], Yuxi Fu[1], Hua Yuan[3], Pengfei Lan[3], Oliver D. Mücke[4,5], Akira Suda[2], Katsumi Midorikawa[1], Eiji J. Takahashi[1]; [1]*RIKEN Center for Advanced Photonics, RIKEN, Japan;* [2]*Tokyo Univ. of Science, Japan;* [3]*School of Physics and Wuhan National Lab of Optoelectronics, Huazhong Univ. of Science and Technology, China;* [4]*Center for Free-Electron Laser Science, DESY, Germany;* [5]*The Hamburg Centre for Ultrafast Imaging, Germany.* A three-channel optical waveform synthesizer is demonstrated for generating intense continuum soft-x-ray pulses by HHG. With the full stabilization of temporal delays, relative phases, and CEPs, precision control of shot-to-shot reproducible synthesized waveforms is achieved.

SW4E.8 • 18:45
Extended Propagation of Broadband Space-Time Wave Packets for 70 m, Basanta Bhaduri[1], Murat Yessenov[1], Danielle Harper[1], Jessica Pena[1], Monjurul Meem[2], Shermineh Rostami Fairchild[1], Rajesh Menon[2], Martin Richardson[1], Ayman F. Abouraddy[1]; [1]*Univ. of Central Florida, CREOL, USA;* [2]*Electrical Engineering, Uinversity of Utah, USA.* We synthesize a femtosecond wave packet of 20-nm bandwidth and spatial beam width of 0.7-mm that propagates diffraction-free for 70-m by virtue of carefully engineered spatio-temporal spectral correlations introduced into the field.

Executive Ballroom 210F

SW4F • Terahertz Sources & Communication—Continued

SW4F.6 • 18:30
Low-noise THz-wave generation from a dual-wavelength fiber Brillouin cavity coupled to a UTC-photodiode, Yihan Li[1,2], Antoine Rolland[2], Kenta Iwamoto[3], Naoya Kuse[2], Martin E. Fermann[4], Tadao Nagatsuma[3]; [1]*Beihang Univ., China;* [2]*IMRA America, Inc., Boulder Research Lab, USA;* [3]*Graduate School of Engineering Science, Osaka Univ., Japan;* [4]*IMRA America, USA.* A dual-wavelength photonic system for carrier-frequency-stable THz signal generation is demonstrated. An in-loop fractional frequency instability $<10^{-16}$ via synchronization to an external reference while preserving the intrinsic low phase noise of a Brillouin cavity is experimentally demonstrated.

SW4F.7 • 18:45
Spectral-efficient and high-speed THz-wave communication using 40 Gsymbol/s channel-based Nyquist WDM, Koichi Takiguchi[1]; [1]*Dept. of Electrical and Electronic Engineering, Ritsumeikan Univ., Japan.* Nyquist WDM was adopted to improve spectral-efficiency and capacity of THz-wave communication. 2 x 40 Gbit/s Nyquist WDM communication in the THz-band was implemented, whose signal generation and reception were both assisted by optical processing.

19:00–20:30 Conference Reception, *Grand Ballroom 220B/C*

SW4G • Optical Frequency Synthesis & Microwave Generation—Continued

SW4G.5 • 18:15
Kerr Comb-based Transfer Oscillator for Ultralow Noise Photonic Microwave Synthesis, Erwan Lucas[1], Pierre Brochard[2], Romain Bouchand[1], Stéphane Schilt[2], Thomas Südmeyer[2], Tobias J. Kippenberg[1]; [1]*EPFL, Switzerland;* [2]*UNINE, Switzerland.* We perform optical frequency division of an ultrastable laser by using a crystalline-based Kerr frequency comb as a transfer oscillator. We demonstrate absolute phase noise levels of -110 dBc/Hz at 200-Hz offset from a 14 GHz carrier.

SW4G.6 • 18:30
An optical frequency synthesizer using an integrated erbium tunable laser, Ming Xin[1], Nanxi Li[1], Neetesh Singh[1], Alfonso Ruocco[1], Zhan Su[1], Emir Salih Magden[1], Jelena Notaros[1], Diedrik Vermeulen[1], Erich Ippen[1], Michael R. Watts[1], Franz Kärtner[1]; [1]*MIT, USA.* We demonstrate a self-calibrated optical frequency synthesizer using a fully-integrated erbium-doped tunable laser. A 20 nm tuning range from 1544 nm to 1564 nm is achieved with ~10^{-13} frequency instability at 10s averaging time.

SW4G.7 • 18:45
Comb-rooted synthesis of ultra-narrow multiple optical frequencies of few Hz linewidth, Byung Soo Kim[1], Heesuk Jang[1], Dong-Chel Shin[1], Young-Jin Kim[2,1], Seung-Woo Kim[1]; [1]*South Korea Advanced Inst of Science & Tech, South Korea (the Republic of);* [2]*Nanyang Technological Univ., Singapore.* An optical synthesizer is devised to generate ultra-narrow optical frequencies of a 1.0 Hz linewidth directly from a frequency comb stabilized to a high-finesse cavity.

SW4H • Supercontinuum Generation—Continued

SW4H.5 • 18:15
Supercontinuum Generation from Dispersion Engineered AlN Nanophotonic Waveguide Arrays, Hong Chen[1], Jingan Zhou[1], Houqiang Fu[1], Xuanqi Huang[1], Tsung-Han Yang[1], Kai Fu[1], Jossue Montes[1], Chen Yang[1], Yuji Zhao[1]; [1]*Arizona State Univ., USA.* We experimentally study the supercontinuum generation from AlN nanophotonic waveguide arrays. By splitting the fundamental TE mode into TE-odd and TE-even modes, dispersion property of the waveguide is greatly improved.

SW4H.6 • 18:30
Broadband Supercontinuum Generation from a Tm Oscillator in a Highly Nonlinear Silica Fiber, Junjie Zeng[1], Claude-Alban Ranély-Vergé-Dépré[1], Ahmet Akosman[1], Etienne Genier[1], Michelle Y. Sander[1]; [1]*Boston Univ., USA.* A broadband supercontinuum is generated from a thulium ultrafast fiber laser in a highly nonlinear silica fiber with low nJ input pulse energies.

SW4H.7 • 18:45
Observation of broadband frequency down-conversion by adiabatic four-wave mixing in optical fiber, Xiaoyue Ding[1], Kerrianne Harrington[2], Dylan Heberle[1], Noah Flemens[1], Wei-Zung Chang[1], Tim Birks[2], Jeffrey Moses[1]; [1]*Cornell Univerisity, USA;* [2]*Dept. of Physics, Univ. of Bath, UK.* We present the first experimental observation of broadband adiabatic four-wave mixing frequency conversion by using a tapered photonic crystal fiber to generate 2-μm pulses. This conversion mechanism may prove widely relevant for ultrafast optics applications.

AW4I • Medical Devices & Systems—Continued

AW4I.4 • 18:00 Invited
Autonomous Artificial Intelligence Eye Screening: Roles and Challenges in Retinal Imaging, Kaushal Solanki[1], Jisun Moon[1], Malavika Bhaskaranand[1], Chaithanya Ramachandra[1]; [1]*Eyenuk Inc., USA.* Autonomous AI eye screening can provide a highly accurate, accessible and cost-efficient solution for preventable blindness and can potentially do more. Images are one of the critical data. What can be done with autonomous AI image analysis and the roles and challenges in obtaining retinal images will be discussed.

AW4I.5 • 18:30
Femtosecond Micromachining of Ophthalmic Hydrogels: effects of laser repetition rate on the induced phase change in the two photon and four photon absorption limit, Ruiting Huang[1], Wayne H. Knox[1]; [1]*The Inst. of Optics, USA.* We study and model effects of laser wavelength, repetition rate and other parameters on writing refractive index changes with a femtosecond laser in ophthalmic hydrogels.

AW4I.6 • 18:45
In Vivo En Face and Cross-Sectional Imaging with Mirau-Type Optical Coherence Microscopy Based on a Ti:Sapphire Crystal Fiber Light Source, Tuan-Shu Ho[1], Ming-Rung Tsai[1], Chih-Wei Lu[1]; [1]*Apollo Medical Optics, Taiwan.* With a simple optical switch and a low-cost Ti:sapphire crystal fiber light source, a Mirau-type optical coherence microscopy for both high-speed *en face* and cross-sectional imaging is demonstrated.

19:00–20:30 Conference Reception, *Grand Ballroom 220B/C*

Meeting Room 211 C/D

CLEO: Science & Innovations

SW4J • Design & Simulation of Micro- & Nano-photonic Devices—Continued

SW4J.6 • 18:15
Nanostructured Photonic Power Splitter Design via Convolutional Neural Networks, Keisuke Kojima[1], Mohammad H. Tahersima[1], Toshiaki Koike-Akino[1], Devesh Jha[1], Bingnan Wang[1], Chungwei Lin[1], Kieran Parsons[1]; [1]*Mitsubishi Electric Research Labs, USA.* We train a convolutional neural network (CNN) that can predict the optical response of randomly generated nanopatterned photonic power splitters in a 2^{400} design space with a prediction correlation coefficient of 85 %.

SW4J.7 • 18:30
Adjoint-based inverse design of nonlinear nanophotonic devices, Tyler Hughes[1], Momchil Minkov[1], Ian Williamson[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We extend the frequency-domain adjoint method to nonlinear optical systems, which enables the gradient-based optimization and inverse design of novel devices. As illustrations, we devise compact photonic switches in a Kerr nonlinear material.

SW4J.8 • 18:45
Topology Optimization of Large-Area Metasurfaces, Zin Lin[2], Victor Liu[3], Raphael Pestourie[1], Steven Johnson[2]; [1]*Harvard Univ., USA;* [2]*Mathematics, MIT, USA;* [3]*--, USA.* We demonstrate an inverse design technique for metasurfaces, based on topology optimization, that can take into account electromagnetic interactions over large surface areas. As an example, we present a multi-layered metalens design that can concentrate multiple beams onto a single focus.

Meeting Room 212 A/B

CLEO: Applications & Technology

AW4K • Lidar—Continued

AW4K.5 • 18:15
Silicon Nitride Optical Phased Arrays with Cascaded Phase Shifters for Easy and Effective Electronic Control, Shiyang Zhu[1], Yu Li[1], Ting Hu[1], Qize Zhong[1], Yuan Dong[1], Zhengji Xu[1], Navab Singh[1]; [1]*Inst. of Microelectronics, Singapore.* We present integrated optical phased arrays with cascaded phase shifting architectures for easy and effective electronic control. A 32-element SiN OPA was measured to exhibit 16° continuous steering at 13-V bias with 0.7° beam width.

AW4K.6 • 18:30
Efficient Ho:LuLiF MOPA Laser Transmitter with Tailored Pulse Width and Output Energy for Space-Based Coherent Wind Lidar, Jane Lee[1,2], Jirong Yu[2], Teh-Hwa Wong[1,2], Larry Petway[2], Songsheng Chen[2], Michael J. Kavaya[2]; [1]*Science Systems & Applications, Inc., USA;* [2]*NASA Langley Research Center, USA.* A Ho:LuLiF MOPA laser system that generates 75 mJ energy and 200 ns pulse width at 200 Hz PRF was developed for coherent wind lidar measurements, fulfilling the lidar system's figure-of-merit and accuracy requirements.

Meeting Room 212 C/D

CLEO: Science & Innovations

SW4L • Optical Detection of Vapors or Hazardous Environments—Continued

SW4L.6 • 18:15
Characterization of a Laser-Induced Plasma Using Time-Resolved Dual-Frequency-Comb Spectroscopy, Yu Zhang[2,1], Caroline Lecaplain[1], Reagan R. Weeks[1], Jeremy Yeak[4], Sivanandan S. Harilal[3], Mark C. Phillips[3], R. J. Jones[1]; [1]*College of Optical Sciences, Univ. of Arizona, USA;* [2]*Dept. of Physics, Univ. of Arizona, USA;* [3]*Pacific Northwest National Lab, USA;* [4]*Opticslah, USA.* We characterize the dynamics of laser-induced plasmas using time-resolved dual-frequency-comb spectroscopy. The temporal evolution of plasma's temperature, population number density are estimated for multiple Fe transitions.

SW4L.7 • 18:30 Invited
High-Performance Micro-Gas Chromatography and Optical Sensing, Xudong Fan[1]; [1]*Univ. of Michigan, USA.* Micro-gas chromatography (micro-GC) devices have broad applications in vapor analysis. Here we describe various optical vapor sensors that can be used in micro-GC, including ring resonators, fiber Fabry-Perot cavities, interferometric sensors, and micro-photoionization detectors.

19:00–20:30 Conference Reception, *Grand Ballroom 220B/C*

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

FW4M • Advanced Techniques & Applications in Ultrafast Spectroscopy—Continued

FW4M.5 • 18:30
Ultrafast Spin Dynamics and Phase Competition in a Spin Vortex Crystal Superconductor, Di Cheng[1,2], Joongmok Park[1,2], Liang Luo[1,2], Richard H. Kim[1,2], William Meier[1,2], Sergey Bud'ko[1,2], Paul Canfield[1,2], Martin Mootz[3], Ilias E. Perakis[3], Jigang Wang[1,2]; [1]*Iowa State Univ, USA;* [2]*Ames Lab, USA;* [3]*Physics, Univ. of Alabama at Birmingham, USA.* Ultrafast spectroscopy measurements on iron pnictide 1144 superconductor $CaK(Fe_{1-x}Ni_x)_4As_4$ revealed, for the first time, spin dynamics of an exotic Spin Vortex Crystal (SVC) phase that competes with superconductivity.

FW4M.6 • 18:45
Carrier Dynamics Between the Ordered and Disordered Orthorhombic Lattice Domains in Methylammonium Lead Iodide Perovskite, Michael Titze[1], Chengbin Fei[2], Maria Munoz[1], He Wang[2], Hebin Li[1]; [1]*Florida International Univ., USA;* [2]*Physics, Univ. of Miami, USA.* The carrier dynamics between the ordered and disordered orthorhombic lattice domains in methylammonium lead iodide perovskite are measured. Emission from disordered domain is visible within 250fs, accessing intermediate states inbetween and coupling to coherent phonon.

Marriott
Salon III

CLEO: Science & Innovations

SW4N • High Power & Narrow Linewidth Lasers—Continued

SW4N.5 • 18:15
Frequency Noise Reduction in a Quantum Cascade Laser Using a Short Free-Space Delay Line, Atif Shehzad[1], Pierre Brochard[1], Renaud Matthey[1], Thomas Südmeyer[1], Stéphane Schilt[1]; [1]*Univ. of Neuchatel, Switzerland.* We present a frequency noise reduction in a mid-infrared quantum cascade laser achieved by stabilization to a short free-space delay line and show a decrease by more than 20 dB at 1-kHz Fourier frequency.

SW4N.6 • 18:30
1550 nm laser with 320 Hz Lorentzian linewidth based on semiconductor gain chip and extended Si3N4 Bragg grating, Chao Xiang[1], Paul Morton[2], John Bowers[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of California Santa Barbara, USA;* [2]*Morton Photonics, USA.* We demonstrate narrow linewidth lasers based on a semiconductor gain chip coupled to a Si3N4 Bragg grating. The laser demonstrates 12 mW fiber coupled output power, > 55 dB SMSR and 320 Hz Lorentzian linewidth.

SW4N.7 • 18:45
Mutually Coupled Distributed Feedback Lasers with 10 Hz Intrinsic Linewidth, Weichao Ma[1], Bing Xiong[1], Changzheng Sun[1], Xu Ke[1], Jian Wang[1], Zhibiao Hao[1], Lai Wang[1], Yanjun Han[1], Hongtao Li[1], Yi Luo[1]; [1]*Dept. of Electronic Engineering, Tsinghua Univ., China.* Pronounced linewidth narrowing in mutually injection locked distributed feedback lasers is confirmed by local oscillator heterodyne and delayed self-heterodyne measurements. White frequency noise of 3 Hz^2/Hz is recorded, corresponding to 10 Hz intrinsic linewidth.

Marriott
Salon IV

SW4O • Short-Reach Communication Technologies—Continued

SW4O.6 • 18:30
Combined Probabilistic Shaping and Nyquist Pulse Shaping for PAM8 Signal Transmission in WDM Systems, Xiao Han[1,2], Mingwei Yang[1], Ivan B. Djordjevic[1], Yang Yue[2], Qiang Wang[2], Zhen Qu[2], Jon Anderson[2]; [1]*Electrical and Computer Enginering, Univ. of Arizona, USA;* [2]*Juniper Networks, USA.* We use the LDPC-coded probabilistically shaped PAM8 signaling combined with Nyquist pulse shaping to improve the transmission performance in a WDM system. We find that the combination of these shaping schemes offers great performance improvement.

19:00–20:30 Conference Reception, *Grand Ballroom 220B/C*

NOTES

07:30–18:00 Registration, *Concourse Level*

CLEO: QELS-Fundamental Science

Executive Ballroom 210A

08:00–10:00
FTh1A • Exploiting Quantum Degrees of Freedom
Presider: John Sipe, University of Toronto, Canada

FTh1A.1 • 08:00 Tutorial
Quantum Information Science with Integrated Optics and Pulsed Light, Christine Silberhorn[1]; [1]*Universität Paderborn, Germany.* Photonic networks with many modes and quantum input states have been proposed for various quantum applications. Here we present three approaches to overcome current limitations for their implementation: nonlinear integrated quantum optics, temporal modes and time-multiplexing.

Christine Silberhorn is a professor at Paderborn University leading the research group "Integrated Quantum Optics". She received several prizes, most prominently: Gottfried-Wilhelm-Leibniz-prize from the German Science Foundation (2011) and a consolidator ERC-grant (2017). Since 2013 she is member of the Leopoldina, National Academy of Science, and since 2018 OSA Fellow.

Executive Ballroom 210B

08:00–10:00
FTh1B • Ultrafast Nonlinear Phenomena
Presider: To Be Announced

FTh1B.1 • 08:00 Invited
Optical Picoscopy of Valence Electrons in Solids, Harshit Lakhotia[2,1], Eleftherios Goulielmakis[2,1]; [1]*Max-Planck-Institut fur Quantenoptik, Germany;* [2]*Univ. of Rostock, Germany.* We demonstrate that strong field driven high harmonic generation in solids allow aquiring real space pictures of the electronic potential and the electorn density. Our approach provides new ways for probing the basic chemical, optical and electronic properties of solids.

FTh1B.2 • 08:30
Subcycle observation of terahertz-driven minimally dissipative spin switching, Stefan Schlauderer[1], Christoph Lange[1], Sebastian Baierl[1], Thomas Ebnet[1], Christoph Schmid[1], Darren C. Valovcin[2], Anatoly K. Zvezdin[3,4], Alexey Kimel[5,6], Rostislav Mikhaylovskiy[6], Rupert Huber[1]; [1]*Univ. of Regensburg, Germany;* [2]*Dept. of Physics and the Inst. for Terahertz Science and Technology, Univ. of California at Santa Barbara, USA;* [3]*Prokhorov General Physics Inst. and P.N. Lebedev Physical Inst., Russia;* [4]*Moscow Inst. of Physics and Technology (State Univ.), Russia;* [5]*Moscow Technological Univ. (MIREA), Russia;* [6]*Radboud Univ., Netherlands.* Antenna-enhanced single-cycle terahertz pulses ballistically switch the antiferromagnetic spin order in $TmFeO_3$ between metastable states separated by a potential energy barrier. We directly trace the temporal and spectral fingerprint of this ultrafast minimally dissipative dynamics.

Executive Ballroom 210C

08:00–10:00
FTh1C • Hot-electron Enabled Plasmonics & Optical Vortices
Presider: Ido Kaminer Technion, Israel

FTh1C.1 • 08:00
Hot carriers generated by plasmons: where they are born, where they are going and how they die, Jacob Khurgin[1]; [1]*Johns Hopkins Univ., USA.* A unified theory of plasmon-induced hot carrier generation in metals is developed with all the relevant mechanisms included. Analytical expressions for carrier generation rates, their locations, energies and directions of motion are obtained.

FTh1C.2 • 08:15
Hot Carrier Induced Plasmon Enhanced Photocatalysis in Hematite Thin Films, Aveek Dutta[1], Alberto Naldoni[2], Alexander Govorov[3,4], Vladimir M. Shalaev[1], Alexandra Boltasseva[1]; [1]*Purdue Univ., USA;* [2]*Regional Center for Advanced Technologies and Materials, Czechia;* [3]*Ohio Univ., USA;* [4]*Univ. of Electronic Science and Technology of China, China.* We experimentally demonstrate photocurrent enhancement in thin hematite films due to a combination of enhanced scattering from plasmonic nanodisks and hot carriers generated from plasmon decay.

FTh1C.3 • 08:30
Hot Carrier Photodetection From Fractal Aluminum Films In The Near-IR, Christian Frydendahl[1], Meir Grajower[1], Noa Mazurski[1], Joseph Shappir[1], Uriel Levy[1]; [1]*Dept. of Applied Physics, The Hebrew Univ. of Jerusalem, Israel.* Using self-organized random fractal aluminum films, we experimentally observe plasmonically enhanced hot carrier photodetection in p-doped silicon in the short wave infrared wavelength regime, with very high responsivities over a broad range of wavelengths.

Executive Ballroom 210D

08:00–10:00
FTh1D • Entanglement Sources
Presider: Marco Liscidini; Università degli Studi di Pavia, Italy

FTh1D.1 • 08:00
On-demand photonic entanglement synthesizer, Kan Takase[1], Shuntaro Takeda[1,2], Akira Furusawa[1]; [1]*the Univ. of Tokyo, Japan;* [2]*JST, Japan.* We demonstrate on-demand generation of photonic entanglement by dynamicallycontrolling a loop-based circuit at nanosecond timescale. We generate 6 types of entangled states including 1000-mode 1D-cluster states without changing the circuit architecture.

FTh1D.2 • 08:15
Quantum walks and synthetic tight-binding crystals in on-chip electro-optic frequency combs, Christian Reimer[1], Yaowen Hu[1], Mian Zhang[1,2], Amirhassan Shams-Ansari[1], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*HyperLight Corporation, USA.* We investigate the quantum properties of electro-optic frequency combs and measure quantum walks in the frequency-domain as well as the formation of tight-binding crystals in high-dimensional synthetic space. The frequency combs are achieved using an integrated lithium niobite microring resonator.

FTh1D.3 • 08:30
Scalable feedback control of on-chip entangled photon pair sources, Jacques Carolan[1], Uttara Chakraborty[1], Nicholas C. Har-ris[2], Mihir Pant[1], Tom Baehr-Jones[3], Michael Hochberg[3], Dirk R. Englund[1]; [1]*MIT, USA;* [2]*Lightmatter, USA;* [3]*Elenion Technologies, USA.* We develop a feedback control tech-nique for single photon sources based on microring resonators. We implement our protocol on a silicon photonic device, and demonstrate feedback controlled quantum state engineering.

07:30–18:00 Registration, *Concourse Level*

CLEO: Science & Innovations

Executive Ballroom 210E

08:00–10:00
STh1E • Mid-IR Lasers
Presider: Clara Saraceno, Ruhr Universität Bochum, Germany

STh1E.1 • 08:00
Gain-optimized 2.05 µm pulses at 20 mJ and 1 kHz from multi-pass Ho:YLF amplifier, Krishna Murari[1,2], Yanchun Yin[1,2], Yi Wu[1,2], Xiaoming Ren[1,2], Zenghu Chang[1,2]; [1]*College of Optics and Photonics (CREOL), USA;* [2]*Univ. of Central Florida Physics, USA.* We present Ho:YLF based multi-pass amplifier emitting pulses at 20 mJ energy and 1 kHz repetition rate seeded by 3-mJ seed pulses from DC-OPA.

STh1E.2 • 08:15
Selective Wavelength KGW/ Tm:YLF Raman Laser, Salman Noach[1], Uzziel Sheintop[1], Daniel Sebbag[1], Pavel Komm[2], Gilad Marcus[2]; [1]*Jerusalem College of Technology, Israel;* [2]*Applied Physics, Hebrew Univ., Israel.* External cavity Raman laser based on KGW crystal emitting at 2197nm and 2263nm is presented. The efficient use of KGW for 2µm region is demonstrated. Maximum energy of 0.4mJ was achieved, the highest energy reported.

STh1E.3 • 08:30
Robust, high peak power, thulium-doped fiber chirped-pulse amplification system using a dissipative soliton seed laser, Zhengqi Ren[1], Jonathan Price[1], David Richardson[1], Shaif-Ul Alam[1]; [1]*Univ. of Southampton, UK.* We report a dissipative soliton seeded, thulium-doped fiber chirped pulse amplification system at 1950 nm. The amplified pulses are compressed to 545 fs and have an energy of 0.85 µJ corresponding peak power of 1.56 MW.

Executive Ballroom 210F

08:00–10:00
STh1F • Chip-Scale Trace-Gas Sensing
Presider: Eric Zhang; IBM, USA

STh1F.1 • 08:00 Invited
Trace Gas Spectroscopy with Mid-Infrared Nanophotonic Waveguides, Marek Vlk[1], Henock D. Yallew[1], Vinita Mittal[2], Ganapathy Senthil Murugan[2], Jana Jagerská[1]; [1]*UiT The Arctic Univ. of Norway, Norway;* [2]*Optoelectronics Research Centre Southampton, UK.* We present a mid-infrared photonic waveguide platform for sensitive and selective detection of trace gases by means of tunable laser absorption spectroscopy.

STh1F.2 • 08:30
Trace-gas Spectroscopy of Methane using a Monolithically Integrated Silicon Photonic Chip Sensor, Eric J. Zhang[1], Yves Martin[1], Jason S. Orcutt[1], Chi Xiong[1], Martin Glodde[1], Tymon Barwicz[1], Laurent Schares[1], Elizabeth Duch[1], Nathan Marchack[1], Chu C. Teng[2], Gerard Wysocki[2], William M. Green[1]; [1]*IBM T. J. Watson Research Center, USA;* [2]*Electrical Engineering, Princeton Univ., USA.* We present a monolithically integrated photonic sensor incorporating an on-chip III-V laser, detector, sealed reference cell, and sensing waveguide capable of near-infrared absorption spectroscopy of methane near $\lambda = 1651$ nm. Sub-100 ppmv $Hz^{-1/2}$ sensitivities are demonstrated.

Executive Ballroom 210G

08:00–10:00
STh1G • Frequency Comb Spectroscopy

STh1G.1 • 08:00
A Compact Mid-infrared Dual-Comb Spectrometer with 1000 nm of Spectral Coverage, Gabriel Ycas[1,2], Fabrizio R. Giorgetta[1,2], Jacob Friedlein[1,2], Daniel Herman[1,2], Kevin C. Cossel[2], Esther Baumann[1,2], Nathan R. Newbury[2], Ian Coddington[2]; [1]*Univ. of Colorado at Boulder, USA;* [2]*Applied Physics Division, National Inst. of Standards and Technology, USA.* We present a mid-infrared dual-comb spectrometer employing PPLN waveguides that generates a broad 3-4 µm instantaneous spectrum with 5 mW of power. Outdoor spectroscopy is demonstrated and portable operation should be possible.

STh1G.2 • 08:15
Dual-comb spectroscopy with Si_3N_4 waveguides for gas spectroscopy in the 2 µm – 2.5 µm water window, Esther Baumann[1,2], Eli Hoenig[1], Edgar Perez[1], Gabriel Colacion[1], Fabrizio R. Giorgetta[1,2], Kevin C. Cossel[1], Gabriel Ycas[1,2], David Carlson[1], Daniel Hickstein[1], Kartik Srinivasan[1], Scott B. Papp[1,2], Nathan R. Newbury[1], Ian Coddington[1]; [1]*NIST, USA;* [2]*Physics, Univ. of Colorado Boulder, USA.* Dual-comb spectroscopy of CO and CO_2 is reported in the important 2-2.5 µm atmospheric transparency window, using broadening in tailored Si_3N_4 waveguides and extending beyond Si-based fibers' transparency window.

STh1G.3 • 08:30 Invited
Precision Fourier Transform Spectroscopy Using Optical Frequency Combs, Aleksandra Foltynowicz[1]; [1]*Umea Univ., Sweden.* We present recent advances in direct and cavity-enhanced optical frequency comb Fourier transform spectroscopy for precision measurements of entire absorption bands in the near- and mid-infrared wavelength range.

Executive Ballroom 210H

08:00–10:00
STh1H • Optical Resonance-Based Devices
Presider: Lan Yang; Washington University in St Louis, USA

STh1H.1 • 08:00 Invited
Quantum Dot Spins in Micropillar Cavities, Andrew Young[1], Petros Androvitsaneas[1,2], Joeseph Lennon[1], Christian Schneider[3], Sebastian Maier[3], Janna Hinchliff[1], George Atkinson[1], Edmund Harbord[1], Martin Kamp[3], Sven Höfling[3], John G. Rarity[1], Ruth Oulton[1]; [1]*Bristol Univ., UK;* [2]*Univ. of Exeter, UK;* [3]*Univ. of Würzburg, Germany.* We will examine the requirements for generating photonic entanglement using a charged quantum dot in a pillar microcavity. We will discuss how to make an efficient device and parametrise the dynamics of the QD spin.

STh1H.2 • 08:30
Photon Pair Generation and Filtering Using Monolithically Integrated Silicon Micro-disk and Coupled Resonator Optical Waveguide, Rakesh Ranjan Kumar[1], Xinru Wu[1], Hon Ki Tsang[1]; [1]*Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong.* We demonstrate on-chip pair of photons with spectral brightness of 4.84×10^7 pair/s/mW^2/GHz in micro-disk resonator integrated with on-chip tunable filter to provide high isolation of the pump.

07:30–18:00 Registration, *Concourse Level*

Meeting Room 211 A/B

CLEO: Applications & Technology

08:00–10:00
ATh1I • Radiative Cooling & Photovoltaics
Presider: Daniel Law; Boeing, USA

ATh1I.1 • 08:00
Structured Polymers for High-Performance Passive Daytime Radiative Cooling, Jyotirmoy Mandal[1], Nanfang Yu[1], Yuan Yang[1]; [1]*Columbia Univ., USA.* Structured polymer coatings with exceptional solar reflectance (96-99%) and hemispherical long-wave infrared emittance (~97%) are created using a scalable phase inversion technique. The polymer coatings exhibit excellent passive daytime radiative cooling, with a paint-like convenience.

ATh1I.2 • 08:30
All-day Radiative Cooling Using Beam-Controlled Architectures, Lyu Zhou[1], Haomin Song[1], Jian-Wei Liang[2], Matthew H. Singer[1], Ming Zhou[3], Edgars Stegenburgs[2], Nan Zhang[1], Tien Khee Ng[2], Zongfu Yu[3], Boon S. Ooi[2], Qiaoqiang Gan[1]; [1]*State Univ. of New York at Buffalo, USA;* [2]*KAUST Nanophotonics Lab, King Abdullah Univ. of Science and Technology, Saudi Arabia;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Wisconsin, Madison, USA.* We report an inexpensive planar polydimethylsiloxane (PDMS)/metal thermal emitter in a beam-controlled architecture for all-day radiative cooling and realized ~11 °C reduction compared with the ambient temperature.

Meeting Room 211 C/D

CLEO: Science & Innovations

08:00–10:00
STh1J • Nonlinear Photonics
Presider: Satoshi Iwamoto; Univ. of Tokyo, Japan

STh1J.1 • 08:00
Third- and Fourth-Harmonic Generation in Cascaded Periodically-Poled Lithium Niobate Ultracompact Waveguides on Silicon, Tracy Sjaardema[1], Ashutosh Rao[1,2], Sasan Fathpour[1]; [1]*The College of Optics and Photonics, CREOL, Univ. of Central Florida, USA;* [2]*NIST, Univ. of Maryland, USA.* Cascaded harmonic generation is demonstrated in submicron thin-film periodically poled lithium niobate nonlinear waveguides on a silicon substrate. Harmonics to the third and fourth order are produced through second-harmonic and sum-frequency generation.

STh1J.2 • 08:15
Cavity-enhanced optical parametric generation in a modal-phase-matched lithium niobate microring, Rui Luo[1], Yang He[1], Hanxiao Liang[1], Mingxiao Li[1], Jingwei Ling[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA.* We report cavity-enhanced second-harmonic generation and difference-frequency generation in a high-Q lithium niobate microring resonator with modal phase matching. The second-harmonic generation efficiency is measured to be 1,500% W^{-1}.

STh1J.3 • 08:30 Invited
Beyond Metals and Semiconductors: Nano-Oxides for Nonlinear Photonic Devices, Rachel Grange[1]; [1]*ETH Zurich, Switzerland.* I will show several strategies to maximize nonlinear optical signals in oxide-based materials with noncentrosymmetric crystalline structure, because of their wide bandgap, significant second-order optical nonlinearities, strong electro-optic effects, high damage threshold, and biocompatibility.

Meeting Room 212 A/B

CLEO: Applications & Technology

08:00–10:00
ATh1K • Industrial Metrology & Remote Sensing
Presider: Brian Simonds; National Institute of Standards and Technology, USA

ATh1K.1 • 08:00 Invited
Optical Systems for Industrial Shop Floor Surface Measurements To Improve Yield, Erik L. Novak[1]; [1]*Veeco Instruments Inc, USA.* Abstract not available.

ATh1K.2 • 08:30
3D surface profile imaging based on time-encoded structured illumination, Teng Jiajie[1], Qiang Guo[1], Yuxi Wang[1], Sigang Yang[1], Minghua Chen[1], Hongwei Chen[1]; [1]*Tsinghua Univ., China.* A novel 3D surface profile imaging method based on time-encoded structured illumination is proposed. With fast and arbitrary illumination pattern generation, low error 3D reconstruction of different objects can be obtained.

Meeting Room 212 C/D

CLEO: Science & Innovations

08:00–10:00
STh1L • Hollow Core Fibers
Presider: Meng Zhang; Beihang Univ., USA

STh1L.1 • 08:00
Highly Efficient Thresholdless Ultraviolet Frequency Conversion in H2-filled Photonic Crystal Fiber, David Novoa[1], Manoj K. Mridha[1], Pooria Hosseini[1], Philip S. Russell[1]; [1]*Max-Planck-Inst Physik des Lichts, Germany.* Thresholdless ultraviolet frequency conversion with high efficiency is demonstrated in a hydrogen-filled kagome PCF. Raman coherence waves, prepared by a visible pump, up- or down-shift the frequency of an ultraviolet signal upon fulfillment of phase-matching conditions.

STh1L.2 • 08:30
Gas flow within Hollow Core optical fibers, Matthew Partridge[1], Rowan Curtis[1], Kendra Khodabandehloo[1], Yong Chen[1], tom Bradley[1], Natalie V. Wheeler[1], John Hayes[1], Ian Davidson[1], Seyed Reza Sandoghchi[1], Marco N. Petrovich[1], Francesco Poletti[1], David Richardson[1], Radan Slavik[1]; [1]*Optoelectronics Research Centre, UK.* We demonstrate the use of a Mach-Zehnder interferometer to measure gas flow within hollow core fiber during gas pressure changes. These preliminary results demonstrate the method and indicate differences between various hollow core morphologies.

07:30–18:00 **Registration,** *Concourse Level*

Marriott Salon I & II

CLEO: QELS-Fundamental Science

08:00–10:00
FTh1M • Ultrafast Processes in Gases & Solids
Presider: To Be Announced

FTh1M.1 • 08:00
Self-Reinforced Optical Stability Formed by Unseeded Four-Wave Mixing with Two Pump Beams in Atomic Vapor, Erin Knutson[1], Jon D. Swaim[1], Sara Wyllie[1], Ryan T. Glasser[1]; [1]*Tulane Univ., USA.* We demonstrate unseeded multimode four-wave mixing wherein each created photon is correlated to exactly two others, resulting in an "optimal" four-mode output. The generated beams are spatially separated, readily allowing for use in quantum communications.

FTh1M.2 • 08:15
Laser without population inversion of nitrogen ions pumped by femtosecond pulses, Yi Liu[1,2], Rostyslav Danylo[1,2], Pengji Ding[2], Aurelien Houard[2], Vladimir Tikhonchuk[3], Xiang Zhang[1], Zhengquan Fan[1], Qingqing Liang[1], Songlin Zhuang[1], Luqi Yuan[4], Andre Mysyrowicz[2]; [1]*Univ. of Shanghai for Sci. and Tech., China;* [2]*ENSTA Paristech, France;* [3]*Université de Bordeaux, France;* [4]*Stanford Univ., USA.* We attribute the mechanism of "lasing" action of nitrogen ions pumped by femtosecond IR pulses to a laser without inversion scheme. Numerical simulations reproduce well the temporal dynamics and pressure dependence of the emission.

FTh1M.3 • 08:30
Microwave Radiation from Single and Two Color Mid-Infrared Laser Produced Plasmas in Air, Alexander C. Englesbe[1,2], Robert Schwartz[3], Anastasia Korolov[3], Dogeun Jang[3], Daniel Woodbury[3], Ki-Yong Kim[3], Howard Milchberg[3], Remington Reid[2], Adrian Lucero[2], Hugh Pohle[2], Serge Kalmykov[2], Karl Krushelnick[1], Andreas Schmitt-Sody[2], Jennifer Elle[1]; [1]*Univ. of Michigan, USA;* [2]*Directed Energy Directorate, Air Force Research Lab, USA;* [3]*Univ. of Maryland, USA.* Plasmas generated by focusing ultrashort laser pulses in air emit broadband microwaves. We present comparisons between the frequency spectrum of radiation from 2-70 GHz due to single and two color mid-infrared laser pulses.

Marriott Salon III

CLEO: Science & Innovations

08:00–10:00
STh1N • Sensing & Switching
Presider: Ozdal Boyraz; Univ. of California Irvine, USA

STh1N.1 • 08:00 Invited
Random Fiber Gratings and Applications, Xiaoyi Bao[1]; [1]*Physics Dept., Univ. of Ottawa, Canada.* Enhancing scattering in optical fibers by random periods can lead to broadband grating, which acts as random distributed feedback in lasers to control the coherence for low noise. It can also create multi-parameters sensors.

STh1N.2 • 08:30
Fingerprint mid-infrared sensing with germanium on silicon waveguides, Ugne Griskeviciute[1], Ross Millar[1], Kevin Gallacher[1], Leonetta Baldassarre[2], Marc Sorel[1], Michele Ortolani[2], Douglas J. Paul[1]; [1]*Univ. of Glasgow, UK;* [2]*Sapienza Univ. of Rome, Italy.* Low loss Ge-on-Si waveguides are demonstrated in the 8-14µm atmospheric transmission window for the first time, with losses reaching ~1dB/cm. Molecular fingerprint sensing is demonstrated using a polymer with absorption lines in this spectral region.

Marriott Salon IV

08:00–10:00
STh1O • Metasurfaces & Nanophotonic Materials
Presider: Roberto Paiella; Boston Univ., USA

STh1O.1 • 08:00 Invited
Nonlinear and Tunable Semiconductor Metasurfaces, Isabelle Staude[1]; [1]*Friedrich-Schiller-Univ. Jena, Germany.* Resonant semiconductor metasurfaces were established as a versatile platform for manipulating light fields. This talk reviews our recent advances in the integration of optical nonlinearities into such metasurfaces and on obtaining dynamic control of their optical response.

STh1O.2 • 08:30
Dynamically-tunable Plasmonic Devices Based on Phase Transition of Vanadium Dioxide, Ruwen Peng[1], Fang-Zhou Shu[1], Ren-Hao Fan[1], Mu Wang[1]; [1]*Nanjing Univ., China.* We have experimentally demonstrated several dynamically-tunable plasmonic devices based on phase transition of vanadium dioxide, which include dynamic color generators and dynamically-switchable polarizers. The investigations can be applied in dynamic digital displays and imaging sensors.

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTh1A • Exploiting Quantum Degrees of Freedom—Continued

FTh1A.2 • 09:00
Measuring frequency-bin entanglement in depolarized biphoton frequency combs, Oscar Sandoval[1], Navin B. Lingaraju[1], Poolad Imany[1], Daniel E. Leaird[1], Michael Brodsky[2], Andrew M. Weiner[1]; *[1]Purdue Univ., USA; [2]U.S. Army Research Lab, USA.* A polarization diversity phase modulator capable of measuring frequency-bin entanglement, irrespective of polarization fluctuations and the relative orientation between the signal and idler photons, is demonstrated.

FTh1A.3 • 09:15
High Dimensional Quantum Key Distribution with Biphoton Frequency Combs through Energy-Time Entanglement, Murat C. Sarihan[1], Kai-Chi Chang[1], Xiang Cheng[1,6], Yoo Seung Lee[1], Tian Zhong[2], Hongchao Zhou[3], Zheshen Zhang[4], Franco N. Wong[5], Jeffrey H. Shapiro[5], Chee Wei Wong[1]; *[1]Electrical and Computer Engineering, Univ. of California,Los Angeles, USA; [2]Inst. for Molecular Engineering, Univ. of Chicago, USA; [3]Shandong Univ., China; [4]College of Optical Sciences, Univ. of Arizona, USA; [5]Research Lab of Electronics, MIT, USA; [6]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* Biphoton frequency combs offer a photon-efficient way to achieve a very high-rate quantum key distribution by utilizing both time and frequency-bin encoding, while offering theoretically proven unconditional security.

FTh1B • Ultrafast Nonlinear Phenomena—Continued

FTh1B.3 • 08:45
Experimental Nonlinear Observation of TW Laser Propagation Through a 10m Rubidium Vapor Source for Plasma Diagnostics at AWAKE, Valentina Lee[1], Joshua Moody[2], Gabor Demeter[3], Gregory Kriehn[1], Patric Muggli[2,4]; *[1]California State Univ. Fresno, USA; [2]Max Planck Inst. for Physics, Germany; [3]Wigner Research Center for Physics, Hungary; [4]CERN, Switzerland.* Nonlinear effects from a TW-class laser propagating through a 10m rubidium vapor at AWAKE are experimentally observed. A method of laser field reconstruction via phase retrieval is investigated for the initial conditions of the propagation.

FTh1B.4 • 09:00
Subcycle band structure movie of lightwave-driven Dirac currents, Johannes Reimann[2], Stefan Schlauderer[1], Christoph P. Schmid[1], Fabian Langer[1], Sebastian Baierl[1], Konstantin A. Kokh[3], Oleg E. Tereshchenko[4], Akio Kimura[5], Christoph Lange[1], Jens Güdde[2], Ulrich Höfer[2], Rupert Huber[1]; *[1]Univ. of Regensburg, Germany; [2]Fachbereich Physik, Philipps-Universität, Germany; [3]V.S. Sobolev Inst. of Geology and Mineralogy SB RAS, Russia; [4]A.V. Rzhanov Inst. of Semiconductor Physics SB RAS, Russia; [5]Graduate School of Science, Hiroshima Univ., Japan.* The first subcycle angle-resolved photoemission study reveals how an intense terahertz field drives topologically protected Dirac currents on the surface of Bi_2Te_3. Spin-momentum locking enables fully ballistic lightwave currents over several 100 nm.

FTh1C • Hot-electron Enabled Plasmonics & Optical Vortices—Continued

FTh1C.4 • 08:45
Enhanced Control of Size and Shape of Gold Nanoparticles Produced by a Simple and Scalable Thermal Process, Nathan Ray[1], Jae Hyuck Yoo[1], Hoang Nguyen[1], Mike Johnson[1], Sal Baxamusa[1], Selim Elhadj[1], Joseph Mckeown[1], Manyalibo J. Matthews[1], Eyal Feigenbaum1[1]; *[1]Lawrence Livermore National Lab, USA.* Enhanced control through sub-melting solid state diffusional dewetting is utilized to generate randomly oriented ensembles of nanoparticles on large scales, with controllable regulation over particle size, shape, and separation distance, ideal for large-area plasmonic applications.

FTh1C.5 • 09:00
Full Energy-Momentum Cathodoluminescence Mapping on Circular and Elliptical Plasmonic Bullseye Antennas, Toon Coenen[2,1], Albert Polman[2]; *[1]Delmic, Netherlands; [2]Center for nanophotonics, AMOLF, Netherlands.* We investigate cathodoluminescence emission from circular and elliptical plasmonic bullseye antennas. The emission is mapped both in energy and momentum space, using a novel cathodoluminescence technique in which high-resolution spectroscopy and Fourier imaging are combined.

FTh1C.6 • 09:15
Airy Plasmon Pulses investigated by Multiphoton Photoemission Electron Microscopy (PEEM), Thomas Kaiser[1], Matthias Falkner[1], Amit Singh[1], Matthias Zilk[1], Michael Steinert[1], Thomas Pertsch[1]; *[1]Inst. of Applied Physics, Germany.* We report on multiphoton PEEM measurements of pulsed Airy plasmons generated by a holographic grating.The diffraction-free behavior and high localization are important for generating spatio-temporal electromagnetic hotspots in ultrafast nanophotonics.

FTh1D • Entanglement Sources—Continued

FTh1D.4 • 08:45
Highly Directional Silicon Microring Photon Pair Source, Jeffrey A. Steidle[1], Michael Fanto[1,2], Stefan F. Preble[1], Christopher C. Tison[2], Paul M. Alsing[2]; *[1]Rochester Inst. of Technology, USA; [2]Air Force Research Lab, USA.* Silicon microrings make for compact, tunable photon-pair sources but typically suffer from an effective 50% loss. Through interferometric coupling, these sources can be highly directional, resulting an drastically improved performance.

FTh1D.5 • 09:00
Towards a source of entangled photon pairs in gallium phosphide, Paulina S. Kuo[1], Peter G. Schunemann[2], Mackenzie Van Camp[2], Varun B. Verma[3], Thomas Gerrits[3], Sae Woo Nam[3], Richard P. Mirin[3]; *[1]Information Technology Lab, NIST, USA; [2]BAE Systems, USA; [3]Physical Measurement Lab, National Inst. of Standards and Technology, USA.* We investigate parametric down-conversion in orientation-patterned GaP. Pumped at 865 nm, the signal and idler are at 1350 nm and 2400 nm, respectively.

FTh1D.6 • 09:15
Spontaneous Parametric Down-Conversion in Integrated Hybrid Si_xN_y-PPLN Waveguides for High-Dimensional Qubit Entanglement, Xiang Cheng[3,1], Murat C. Sarihan[1], Kai-Chi Chang[1], Yoo Seung Lee[1], Fabian Laudenbach[2], Zhongyuan Yu[3], Chee Wei Wong[1]; *[1]Dept. of Electrical Engineering, Univ. of California Los Angeles, USA; [2]Security & Communication Technologies, Center for Digital Safety & Security, AIT Austrian Inst. of Technology GmbH, Austria; [3]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* We design a hybrid Si_xN_y and PPLN waveguide for high-purity type-II SPDC generation with modeled normalized efficiency of 225%[$W^{-1}cm^{-2}$]. High-dimensional entanglement via this source is predicted by HOM revival with visibility up to 99.79%.

CLEO: Science & Innovations

STh1E • Mid-IR Lasers—Continued

STh1E.4 • 08:45
CO_2 Laser Optically Pumped by a Tunable 4.3 µm Laser Source, Dana Tovey[1], Jeremy Pigeon[2], Sergei Tochitsky[1], Gerhard Louwrens[1], Ilan Ben-Zvi[2], Chan Joshi[1], Dmitry Martyshkin[3], Vladimir Fedorov[3], Krishna Karki[3], Sergey Mirov[3]; *[1]UCLA, USA; [2]Stony Brook Univ., USA; [3]Univ. of Alabama, Birmingham, USA.* A 10 µm CO2 laser optically pumped by a tunable Fe:ZnSe laser is reported. Gain dynamics, slope efficiency, and self-focusing are studied, demonstrating potential use of an optically pumped CO2 medium for picosecond pulse amplification.

STh1E.5 • 09:00
Watt-Level fs-Laser-Written Thulium Waveguide Lasers, Esrom Kifle[2], Pavel Loiko[3], Carolina Romero[4], Javier R. de Aldana[4], Magdalena Aguilo[2], Francesc Diaz[2], Alain Braud[3], Patrice Camy[3], Uwe Griebner[1], Valentin Petrov[1], Xavier Mateos[2]; *[1]Max Born Inst., Germany; [2]Universitat Rovira i Virgili, Spain; [3]Universite de Caen, France; [4]Univ. of Salamanca, Spain.* A continuous-wave depressed-index channel waveguide laser fabricated by fs direct-laser-writing in monoclinic Tm:KLu(WO_4)$_2$ generated 1.07 W at 1.84 µm with a slope efficiency of 69.5%. Passive Q-switching by Cr^{2+}:ZnS resulted in 2.6 ns/6.9 µJ pulses.

STh1E.6 • 09:15
Single-mode Depressed Cladding Buried Waveguide Laser Based on Single-crystal Cr:ZnS, Nikolai Tolstik[1,2], Andrey G. Okhrimchuk[3,4], Michail P. Smayev[4], Vladislav Likhov[4], Evgeni Sorokin[5], Irina T. Sorokina[1,2]; *[1]Dept. of Physics, Norwegian Univ. of Science and Technology, Norway; [2]ATLA Lasers AS, Norway; [3]Fiber Optics Research Center, Russia; [4]Mendeleyev Univ. of Chemical Technolog, Russia; [5]Photonics Inst., TU Wien, Austria.* We report the first single-mode Cr:ZnS depressed cladding buried waveguide laser manufactured by femtosecond laser writing. The laser yields 150 mW average power at 2272 nm wavelength with 11% slope efficiency.

STh1F • Chip-Scale Trace-Gas Sensing—Continued

STh1F.3 • 08:45
Carbon Dioxide Sensing with Low-confinement High-sensitivity Mid-IR Silicon Waveguides, Floria Ottonello-Briano[1], Carlos Errando-Herranz[1], Henrik Rödjegård[2], Hans Martin[2], Hans Sohlström[1], Kristinn B. Gylfason[1]; *[1]Micro and Nanosystems, KTH Royal Inst. of Technology, Sweden; [2]Senseair AB, Sweden.* We present a low-confinement Si waveguide for 4.26 µm wavelength and apply it to sense CO_2 concentrations down to 0.1%. We demonstrate the highest reported waveguide sensitivity to CO_2: 44% of the free-space sensitivity.

STh1F.4 • 09:00
Gas spectroscopy using low threshold mid-infrared radiation generated in Si_3N_4 waveguides, Eirini Tagkoudi[1], Davide Grassani[1], Fan Yang[3], Hairun Guo[2], Tobias J. Kippenberg[2], Camille-Sophie Bres[1]; *[1]EPFL STI IEL PHOSL, Switzerland; [2]EPFL STI IEL LPQM, Switzerland; [3]EPFL SCI STI LT, Switzerland.* We report trace-gas absorption spectroscopy based on the efficient generation of a 3.05 µm dispersive wave in a Si_3N_4 waveguide pumped by a 2.09 µm femtosecond mode-locked fiber laser.

STh1F.5 • 09:15
An Affordable, Customizable, and Highly Sensitive Metasurface-Based Refractive Index Sensor, Adam Ollanik[1], Isaac O. Oguntoye[1], George Z. Hartfield[1], Matthew D. Escarra[1]; *[1]Tulane Univ., USA.* We demonstrate a compact, metasurface-based sensor. Techno-economic analysis predicts a ~$2,400 device capable of detecting changes in the refractive index of a liquid of ~2*10-8; prototype demonstrates 820% change in transmittance per refractive index unit.

STh1G • Frequency Comb Spectroscopy—Continued

STh1G.4 • 09:00
Adaptive Sampling Terahertz Dual-Comb Spectroscopy Based on a Free-Running Single-Cavity Dual-Comb Fiber Laser, Jie Chen[3,1], Kuzuki Nitta[1,2], Xin Zhao[3], Takahiko Mizuno[1,2], Takeo Minamikawa[1,2], Zheng Zheng[3], Takeshi Yasui[1,2]; *[1]Tokushima Univ., Japan; [2]JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan; [3]Beihang Univ., China.* Mode-resolved adaptive sampling terahertz dual comb spectroscopy is demonstrated using afree-running wavelength-multiplexed dual-comb fiber laser, which illustrates the capability of such single-cavity dual-comb sources for high-precision THz spectroscopy.

STh1G.5 • 09:15
Time-Resolved Dual Frequency Comb Spectroscopy for Broadband Multi-Species Detection in Laser-Induced Plasmas, Caroline Lecaplain[1], Yu Zhang[2,1], Reagan R. Weeks[1], Jeremy Yeak[3], Sivanandan S. Harilal[4], Mark C. Phillips[4], R. J. Jones[1]; *[1]College of Optical Sciences, Univ. of Arizona, USA; [2]Physics, Univ. of Arizona, USA; [3]Opticslah, USA; [4]Pacific Northwest National Lab, USA.* We present the first results using time-resolved broadband dual-comb spectroscopy in a laser-induced plasma. Preliminary results identifying multiple species in a Nd magnet will be shown.

STh1H • Optical Resonance-Based Devices—Continued

STh1H.3 • 08:45
Thermo-refractive noise in silicon nitride microresonators, Guanhao Huang[1], Erwan Lucas[1], Junqiu Liu[1], Arslan Raja[1], Grigory Lihachev[2,3], Michael L. Gorodetsky[2,3], Nils Engelsen[1], Tobias J. Kippenberg[1]; *[1]Inst. of Physics (IPHYS), EPFL, Switzerland; [2]Faculty of Physics, M.V. Lomonosov Moscow State Univ., Russia; [3]Russian Quantum Centre, Russia.* Thermodynamic noises limit the frequency stability of resonators. Here, we present the first complete characterization of thermo-refractive noise in Si_3N_4 microresonators. The measurements are in good agreement with theoretical analysis and FEM simulation of the structures.

STh1H.4 • 09:00
All–Optical Control of Pulse Storage Time and Retrieval Phase Using a Diamond Microdisk, Matthew Mitchell[1], David Lake[1], Paul E. Barclay[1]; *[1]Physics & Astronomy, Univ. of Calgary, Canada.* Enhancement of optomechanical pulse storage time is demonstrated, for the first time, in a multimode diamond microdisk cavity. Optical control of the mechanical damping rate and frequency allows > 5× enhancement of the pulse storage time, and a maximum controllable pulse phase shift of ~2π.

STh1H.5 • 09:15
Record-High-Q Microresonators from 650 nm to 1550 nm Wavelengths on a 3C-SiC-on-Insulator Platform, Tianren Fan[1], Xi Wu[1], Ali Eftekhar[1], Ali Adibi[1]; *[1]Georgia Inst. of Technology, USA.* We report record-high-Q SiC microresonators on a 3C-SiC-on-insulator platform with ultra-low (~1.4 Å) roughness after chemical-mechanical polishing. We demonstrate Qs of 242,000 at 1550 nm, 112,000 at 780 nm, and 83,000 at 650 nm.

Meeting Room 211 A/B

CLEO: Applications & Technology

ATh1I • Radiative Cooling & Photovoltaics—Continued

ATh1I.3 • 08:45
Boosted CO_2 Reduction Using Ultra-thin TiO_2 Photocatalyst Films on Nanocavities, Haomin Song[1], Wei Wu[2], Jian-Wei Liang[3], Partha Maity[4], Omar F. Mohammed[4], Boon S. Ooi[3], Dongxia Liu[2], Qiaoqiang Gan[1]; [1]*State Univ. of New York at Buffalo, USA;* [2]*Dept. of Chemical & Biomolecular Engineering, Univ. of Maryland College Park, USA;* [3]*Dept. of Electrical Engineering, King Abdullah Univ. of Science and Technology, Saudi Arabia;* [4]*Dept. of Material Science, King Abdullah Univ. of Science and Technology, Saudi Arabia*. We created an ultra-thin film photocatalytic light absorber (UFPLA) with 2~22-nm-thick TiO_2 films. The UFPLA structure conquered the intrinsic trade-off between optical absorption and charge carrier extraction efficiency and therefore boosted CO_2 reduction efficiency.

ATh1I.4 • 09:00
Silicon Solar Cells Efficiency Enhanced In NIR Band by Coating Plasmonics ITO- and UC Phosphors-particles Layers on Back-side Surface Using Spin-on Film Deposition, Ding-Lun Lin[1], Wen-Jeng Ho[1], Guan-Yu Chen[1], Jheng-Jie Liu[1], Bao-Ying Pan[1], Ying-Lun Haung[1], Po-Yuan Ting[1], Xing-Yu Chen[1]; [1]*National Taipei Univ. of Technology, Taiwan.* We demonstrate efficiency enhanced in NIR-band using plasmonics indium-tin-oxide (ITO) nanoparticles and up-conversion (UC)-phosphors particles on back-side of silicon solar cells. Impressive efficiency enhancement of 17.49% was obtained, compared to the reference-cell without ITO/UC-particles.

ATh1I.5 • 09:15
Ultra-Wide Field of View Lens-Let Array for Efficient Solar Collection, Rakan E. Alsaigh[1], Ralf Bauer[2], Martin P. Lavery[1]; [1]*Univ. of Glasgow, UK;* [2]*Univ. of Strathclyde, UK.* Efficient solar collection over a full-day is a leading challenge for photovoltaic power generation. We present a novel multi-layer lens-let array that increases the daily collection efficiency of standard panels by a factor of 2.32.

Meeting Room 211 C/D

CLEO: Science & Innovations

STh1J • Nonlinear Photonics—Continued

STh1J.4 • 09:00
On-Chip Backward Inter-modal Brillouin Scattering, Yang Liu[1], Amol Choudhary[1], Guanghui Ren[2], Duk-yong Choi[3], Alvaro Casas-Bedoya[1], Blair Morrison[1], Pan Ma[3], Thach Nguyen[2], Khu Vu[3], Arnan Mitchell[2], Stephen Madden[3], David Marpaung[4], Benjamin J. Eggleton[1]; [1]*The Univ. of Sydney, Australia;* [2]*RMIT Univ., Australia;* [3]*Australian National Univ., Australia;* [4]*Univ. of Twente, Netherlands.* We present the first demonstration of backward stimulated Brillouin scattering between distinct guided optical spatial modes in an integrated multi-modal photonic circuit. This unique opto-acoustic process enables new opportunities for on-chip Brillouin signal processing technology.

STh1J.5 • 09:15
Efficient and Broadband Four-wave Mixing in AlGaAs Microresonator for High-speed Optical Signal Processing, Chanju Kim[1], Erik Stassen[1], Kresten Yvind[1], Minhao Pu[1]; [1]*DTU Fotonik, Denmark.* We demonstrate four-wave mixing in GHz-linewidth AlGaAs microresonators with -10.7-dB conversion efficiency at 4-mW pump power over the telecom S-, C- and L-bands. We achieve 57-dB resonance enhancement for microresonators supporting 10-Gbit/s signal processing.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATh1K • Industrial Metrology & Remote Sensing—Continued

ATh1K.3 • 08:45
Demonstration of the Hybrid Opto-electronic Correlator for Shift, Scale, and Rotation Invariant Target Recognition, Julian Gamboa[1], Mohamed Fouda[1], Selim M. Shahriar[1]; [1]*Northwestern Univ., USA.* We demonstrate experimentally that our proposed hybrid opto-electronic correlator is capable of detecting objects in a scale, rotation, and shift invariant manner using currently available technologies by incorporating the polar Mellin transform.

ATh1K.4 • 09:00
Ultra-Broadband Photonic Monopulse-Like Radar for Remote Sensing, Bohao Liu[1], Jhih-Min Wun[2], Nathan O'Malley[1], Daniel E. Leaird[1], Nan-Wei Chen[3], Jin-Wei Shi[2], Andrew M. Weiner[1]; [1]*Purdue Univ., USA;* [2]*National Central Univ., Taiwan;* [3]*Yuan Ze Univ., Taiwan.* High depth and transverse resolution remote target sensing using an extremely wide-bandwidth W-band (75 - 110 GHz) photonic monopulse-like radar system is demonstrated, offering prospects for millimeter wave 3-D sensing and imaging.

ATh1K.5 • 09:15
Regularized Phase Reconstruction for Sensing Deep Subwavelength Perturbations on Large-Scale Wafers, Jinlong Zhu[1], Lynford L. Goddard[1]; [1]*Univ. of Illinois at Urbana-Champaign, USA.* We demonstrate that deep subwavelength scale perturbations on large-scale wafers can be inspected using a regularized phase metrology method. This work paves the route to reference-free defect inspection for nanostructures at advanced technology nodes.

Meeting Room 212 C/D

CLEO: Science & Innovations

STh1L • Hollow Core Fibers—Continued

STh1L.3 • 08:45
Brillouin Scattering in Anti-Resonant Hollow-Core Fibers, Arjun Iyer[1], Wendao Xu[1], Jose Enrique Antonio-Lopez[2], Rodrigo Amezcua Correa[2], William H. Renninger[1]; [1]*Inst. of Optics, Univ. of Rochester, USA;* [2]*The College of Optics and Photonics, Univ. of Central Florida, USA.* We investigate optomechanical interactions in anti-resonant hollow-core fibers, for the first time. Experiments and corresponding theoretical calculations reveal weak optomechanical coupling, which suggests that anti-resonant hollow-core fibers are well-suited for noise-sensitive applications.

STh1L.4 • 09:00 Invited
Low Loss Hollow Core Photonic Crystal Fibres: Fabrication to Applications, Natalie V. Wheeler[1], Tom Bradley[1], John Hayes[1], Yong Chen[1], Greg Jasion[1], Ian Davidson[1], Hesham Sakr[1], Eric Numkam Fokoua[1], Seyed Reza Sandoghchi[1], Matthew Partridge[1], Shuichiro Rikimi[1], Simon Bawn[2], Austin Taranta[1], Radan Slavik[1], Marco N. Petrovich[1,2], Francesco Poletti[1], David Richardson[1]; [1]*Univ. of Southampton, UK;* [2]*Lumensity Ltd, UK.* We review our latest progress in the fabrication of ultra low loss hollow core photonic crystal fibres for applications including telecommunications, high power laser delivery and gas sensing.

Marriott Salon I & II

CLEO: QELS-Fundamental Science

FTh1M • Ultrafast Processes in Gases & Solids—Continued

FTh1M.4 • 08:45
Stark shift and gain decay in air lasing of N_2^+, Ladan Arissian[1], Jean-Claude Diels[1], Brian Kamer[1]; [1]*Univ. of New Mexico, Canada*. We present the Stark shift measurement on the individual transition lines of N_2^+ in a pump probe configuration. The time dependence of stark shift of transitions in plasma created by 800 nm filament shows the same time dependence as the gain decay.

FTh1M.5 • 09:00
Electronic quantum coherence in N_2^+ air lasing, Jinming Chen[1,4], Jinping Yao[1], Haisu Zhang[2], Zhaoxiang Liu[1], Bo Xu[1], Wei Chu[1], Lingling Qiao[1], Zhenhua Wang[3], Julien Fatome[2], Olivier Faucher[2], Chengyin Wu[5], Ya Cheng[1,3]; [1]*State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Universite de Bourgogne, France;* [3]*State Key Lab of Precision Spectroscopy, East China Normal Univ., China;* [4]*School of Physical Science and Technology, Shanghai Tech Univ., China;* [5]*State Key Lab for Mesoscopic Physics, School of Physics, Peking Univ., China*. We report on the generation of electronic quantum coherence in the ionized nitrogen molecules. The coherence is revealed by observing N_2^+ air lasing with a near-infrared laser and a delayed mid-infrared laser.

FTh1M.6 • 09:15
Energy Transmission Efficiency of Laser-induced Vortical Filaments, Milos Burger[1], Patrick J. Skrodzki[1], John Nees[1], Igor Jovanovic[1]; [1]*Univ. of Michigan, USA.* We performed characterization and energy transmission measurements of both ordinary and vortical ultrafast filament structures in air. The results appear to stand in favor ofthe reduced ionization losses in the case of vortical filaments.

Marriott Salon III

Marriott Salon IV

CLEO: Science & Innovations

STh1N • Sensing & Switching—Continued

STh1N.3 • 08:45
A low power superconductor-to-optoelectronic interface, Adam McCaughan[1], Sonia Buckley[1], Varun B. Verma[1], Alexander N. Tait[1], Sae Woo Nam[1], Jeff Shainline[1]; [1]*NIST, USA.* We present a ultrahigh-impedance superconducting thermal switch that acts as a superconductor-to-optoelectronic interface. We demonstrated the generation of photons in a cryogenic photonic LED from a low-voltage input, detecting those photons with a waveguide-coupled detector.

STh1N.4 • 09:00
Scalable Space-and-Wavelength Selective Switch Architecture Using Microring Resonators, Qixiang Cheng[1], Meisam Bahadori[1], Madeleine Glick[1], Keren Bergman[1]; [1]*Columbia Univ., USA*. A new architecture for space-and-wavelength selective switch fabrics is proposed. This class of designs built with a combination of microring-based channel-selectors and comb-aggregators completely blocks first-order in-band crosstalk enabling highly-scalable and flexible interconnection networks.

STh1N.5 • 09:15
Broadband Low-loss Non-volatile Photonic Switches Using Phase-Change Materials, Jiajiu Zheng[1], Peipeng Xu[2], Jonathan Doylend[3], Arka Majumdar[1]; [1]*Univ. of Washington, Seattle, USA;* [2]*Key Lab of Photoelectric Materials and Devices of Zhejiang Province, Ningbo Univ., China;* [3]*Silicon Photonic Products Division, Intel Corporation, USA.* Based on the non-volatile GST-on-silicon platform, we demonstrate compact (~30 µm), low-loss (~1dB), and broadband (over 30 nm with crosstalk < −10 dB) 1 × 2 and 2 × 2 photonic directional coupler switches.

STh1O • Metasurfaces & Nanophotonic Materials—Continued

STh1O.3 • 08:45
Programmable self-assembled metasurface for strong field enhancement, Tapajyoti Das Gupta[1], Louis Martin-Monier[1], Arthur Lebris[1], Wei Yan[1], Tung Dang Nguyen[1], Alexis Page[1], Fabien Sorin[1]; [1]*Material science, Ecole Polytechnique Federale de Lausanne, Switzerland.* Self-assembled chalcogenide metasurfaces is proposed for low-cost manufacturing on large-area unconventional substrates. Programmed control over particle arrangement and periodicity yields strong Fano resonances, highlighting novel applications for bio-detection and second harmonic generation.

STh1O.4 • 09:00
Embedded dielectric metasurface based subtractive color filter on a 300mm glass wafer, Zhengji Xu[1], Yuan Dong[1], Yuan-Hsing Fu[1], Qize Zhong[1], Ting Hu[1], Dongdong Li[1], Yu Li[1], Nanxi Li[1], Ying Lin[1], Qunying Lin[1], Shiyang Zhu[1], Navab Singh[1]; [1]*A*STAR, Inst. of Microelectronics, Singapore.* Si metasurface embedded subtractive color filters (SCFs) is firstly demonstrated on a 300mm glass wafer using CMOS-compatible fabrication process. Three transmission dips were observed at 528, 568, and 598 nm wavelengths for different SCF designs.

STh1O.5 • 09:15
Large-area, single material metalens in the visible: An approach for mass-production using conventional semiconductor manufacturing techniques, Joon-Suh Park[1], Shuyan Zhang[1], Alan She[1], Wei-Ting Chen[1], Kerolos M. Yousef[1,2], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*Univ. of Waterloo, Canada.* We present mass-producible, large area, single-material metalens working in the visible wavelength, using conventional deep-ultraviolet (DUV) stepper lithography technique. Having a diameter of 1 cm, our present lens show polarization independent, near-diffraction limited focusing behavior.

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTh1A • Exploiting Quantum Degrees of Freedom—Continued

FTh1A.4 • 09:30
High-dimensional one-way quantum computation operations with on-chip optical *d*-level cluster states, Christian Reimer[1,2], Michael Kues[2], Stefania Sciara[2], Piotr Roztocki[2], Mehedi Islam[2], Luis Romero Cortes[2], Yanbing Zhang[2], Bennet Fischer[2], Sebastien Loranger[3], Raman Kashyap[3], Alfonso Cino[4], Sai Chu[5], Brent Little[6], David Moss[7], Lucia Caspani[8], William Munro[9], Jose Azana[2], Roberto Morandotti[2]; [1]*Harvard Univ., USA;* [2]*INRS-EMT, Canada;* [3]*Polytechnique Montreal, Canada;* [4]*Univ. of Palermo, Italy;* [5]*City Univ. of Hong Kong, China;* [6]*Xi'an Inst. of Optics and Precision Mechanics, China;* [7]*Swinburne Univ. of Technology, Australia;* [8]*Univ. of Strathclyde, UK;* [9]*NTT Basic Research Labs, Japan.* We implement on-chip generation of hyper-entangled states in the time- and frequency-domain, and transform them into *d*-level cluster states using a deterministic controlled phase gate. We then demonstrate one-way quantum computing operations and show the state's high tolerance towards noise.

FTh1A.5 • 09:45
Optical Information Processing with Noise-Resistant Entangled Topological States, Alexander V. Sergienko[1], David Simon[1,2], Shuto Osawa[1]; [1]*Boston Univ., USA;* [2]*Stonehill College, USA.* Linear-optical photonic quantum walks are used to jointly entangle polarization and winding number. This joint entanglement allows polarization entanglement-based quantum information processing tasks to be performed with high degree or error protection.

FTh1B • Ultrafast Nonlinear Phenomena—Continued

FTh1B.5 • 09:30
Sub-milijoule, 3 µm optical parametric chirped-pulse amplifier at 10 kHz repetition rate, Xiao Zou[2,1], Wenkai Li[2,1], Houkun Liang[2], Shizhen Qu[2,1], Kun Liu[2,1], Qijie Wang[1], Ying Zhang[2]; [1]*Nanyang Technological Univ., Singapore;* [2]*Singapore Inst. of Manufacturing Technology, Singapore.* We demonstrate a 3 µm optical parametric chirped pulse amplifier with 802 µJ pulse energy, at 10 kHz repetition rate, and stable carrier-envelope phase. 73 fs pulse width is obtained with an efficient nonlinear compression.

FTh1B.6 • 09:45
Nonlinear Generation of Ultrafast beams with Classical Non-Separable States of Light, Ravi Saripalli[1], Anirban Ghosh[1], Apurv C. Nellikka[2], Goutam Samanta[1]; [1]*Atomic, molecular and optical physics division, Physical Research Lab, India;* [2]*Tecnologico de Monterrey, Mexico.* We report on nonlinear generation of ultrafast optical beams with classical non-separable states in spin and orbital angular momentum degrees-of-freedom with topological order as high as 24 and output power as high as 20 mW.

FTh1C • Hot-electron Enabled Plasmonics & Optical Vortices—Continued

FTh1C.7 • 09:30
Dynamics of Decelerating Plasmonic Vortex Cavities, Grisha Spektor[1], Anna-Katharina Mahro[2], Eva Prinz[2,4], Michael Hartelt[2], Deirdre Kilbane[2,3], Martin Aeschlimann[2], Meir Orenstein[1]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*Dept. of Physics, Kaiserslautern Univ., Germany;* [3]*Telecommunications Software & Systems Group, Waterford Inst. of Technology, Ireland;* [4]*Graduate School Materials Science in Mainz, Germany.* We experimentally demonstrate plasmonic decelerating vortex cavities generating a succession of surface-confined vortex pulses carrying temporally-increasing orbital angular momentum. Using ultra-flat gold surface, we spatiotemporally resolve the evolution within the cavities over 300 femtoseconds.

FTh1C.8 • 09:45
Brownian Dynamics Controlled by Phase Gradients, Cristian Hernando Acevedo[1], Jose Guzman-Sepulveda[1], Aristide Dogariu[1]; [1]*Univ. of Central Florida, USA.* We demonstrate the effect of random forces induced by phase gradients on the dynamics of small particles. We show that subdiffusive regimes could be controlled by the topological charge of an external optical field.

FTh1D • Entanglement Sources—Continued

FTh1D.7 • 09:30
Telecom Narrow Bandwidth Two-photon Source with High Fidelity Polarization Entanglement, Kazuya Niizeki[1], Daisuke Yoshida[1], Mingyang Zheng[2], Xiuping Xie[2], Kotaro Okamura[3], Nobuyuki Takei[4], Tomoyuki Horikiri[1,5]; [1]*Yokohama National Univ., Japan;* [2]*Jinan Inst. of Quantum Technology, China;* [3]*Kanagawa Univ., Japan;* [4]*Kyoto Univ., Japan;* [5]*JST PRESTO, Japan.* We demonstrate two-photon sources for long-distance quantum communication. The highest spectral brightness 3.94×10^5 pairs/(s MHz mW), the narrowest linewidth in telecom of 1.06 MHz and entanglement fidelity of 91.8% are shown.

FTh1D.8 • 09:45
Satellite-Borne High-Brightness Source of Entangled Photons, Yuan Cao[1]; [1]*Univ of Science and Technology of China, China.* The satellite-borne high-brightness source of polarization-entangled photons was developed and launched with the "Micius" quantum science satellite. With this source we implemented the Bell test between the satellite and the ground stations over 1200 km.

10:00–11:30 Exhibit Open (10:00–15:00), Coffee Break (10:00–11:30), *Exhibit Halls 1–3*
Coffee Break Sponsored by COHERENT and THORLABS

10:15–12:00 Technology Transfer Program, *Exhibit Hall Theater I*

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H

CLEO: Science & Innovations

STh1E • Mid-IR Lasers—Continued

STh1E.7 • 09:30
Mid-IR Optical Refrigeration: Optical Cryocoolers and Radiation Balanced Lasers, Saeid Rostami[1], Azzurra Volpi[1], Alexander R. Albrecht[1], Mauro Tonelli[2], Mansoor Sheik-Bahae[1]; *[1]Univ. of New Mexico, USA; [2]NEST-CNR, Dipartimento di Fisica, Universita` di Pisa, Italy.* Optical refrigeration in Tm- and Ho-doped crystals is investigated, and their external quantum efficiency, background absorption, and minimum achievable temperatures are reported. Potential of these crystals for mid-IR cryocoolers and radiation balanced lasers are discussed.

STh1F • Chip-Scale Trace-Gas Sensing—Continued

STh1F.6 • 09:30
Suspended Membrane InGaAs Photonic Crystal Waveguides for ammonia sensing at Lambda=6.15um., Kyoung Min Yoo[1], Jason Midkiff[1], Ali Roastamian[1], Swapnajit Chakravarty[2], Ray T. Chen[1,2]; *[1]Electrical and Computer Engineering, The Univ. of Texas at Austin, USA; [2]Omega Optics Inc., USA.* Fully suspended InGaAs waveguide devices with holey photonic crystal waveguides (HPCWs) are designed for mid-infrared sensing at labmda=6.15um in the low index contrast InGaAs-InP platform. We experimentally detect 5ppm ammonia in 1mm long suspended HPCWs.

STh1F.7 • 09:45
Waveguide-Enhanced Raman Spectroscopy Using a Mesoporous Silica Sorbent Layer for Volatile Organic Compound (VOC) Sensing, Haolan Zhao[1,2], Ali Raza[1,2], Bettina Baumgartner[3], Stephane Clemmen[1,2], Bernhard Lendl[3], Andre Skirtach[4], Roel Baets[1,2]; *[1]Photonics Research Group, INTEC, Gent Univ., Belgium; [2]Center for Nano- and Biophotonics, Ghent Univ., Belgium; [3]Inst. of Chemical Technologies and Analytics, Technische Universität Wien, Austria; [4]Dept. of Molecular Biotechnology, Ghent Univ., Belgium.* We report a Raman sensor for broadband vapor-phase volatile organic compounds (VOCs) based on SiN waveguides functionalized with a mesoporous silica top-cladding. A detection limit below 1000ppm is demonstrated and scaling to trace-gas-levels is discussed.

STh1G • Frequency Comb Spectroscopy—Continued

STh1G.6 • 09:30
Singular spectrum analysis for low SNR signal processing in dual-comb distance measurements, Hui Cao[1], Youjian Song[1], Runmin Li[1], Yuepeng Li[1], Ming-lie Hu[1], Chingyue Wang[1]; *[1]Tianjin Univ., China.* We utilize singular spectrum analysis based post-processing approach to reduce distance measurement uncertainty for moving targets in dual-comb absolute ranging.

STh1G.7 • 09:45
Nanophotonic supercontinuum based mid-infrared dual-comb spectroscopy, Hairun Guo[1], Wenle Weng[1], Junqiu Liu[1], Fan Yang[2], Wolfgang Hänsel[3], Camille-Sophie Bres[4], Luc Thévenaz[2], Ronald Holzwarth[3], Tobias J. Kippenberg[1]; *[1]LPQM, École Polytechnique Fédérale de Lausanne, Switzerland; [2]GFO, École Polytechnique Fédérale de Lausanne, Switzerland; [3]Menlo Systems GmbH, Germany; [4]PHOSL, École Polytechnique Fédérale de Lausanne, Switzerland.* We demonstrate a broadband mid-infrared dual-comb spectroscopy for parallel gas-phase detection in the functional group region from 2800—3600cm^{-1}, using dispersion engineered silicon nitride dual-core waveguides which produce broadband, intensity-enhanced and coherent mid-infrared frequency combs.

STh1H • Optical Resonance-Based Devices—Continued

STh1H.6 • 09:30
Fabry-Perot Cavity Using Two Row Photonic Crystal in a Multimode Waveguide, Manuel Mendez-Astudillo[1], Hideaki Okayama[2], Tomohiro Kita[1]; *[1]Waseda Univ., Japan; [2]Research & Development Center, Oki Electric Industry Co., Ltd, Japan.* We experimentally present a Fabry-Perot cavity that uses two-row photonic crystals in a multimode waveguide as the reflecting elements in an add-drop configuration to achieve fine FSR tuning and maximum footprint efficiency.

STh1H.7 • 09:45
New Resonance Behavior based on Bound States in the Continuum in a Silicon Photonic Waveguide Platform, Thach Nguyen[1], Guanghui Ren[1], Steffen Schoenhardt[1], Markus Knoerzer[1], Andreas Boes[1], Arnan Mitchell[1]; *[1]School of Engineering, RMIT Univ., Australia.* A new type of resonance in silicon photonics is demonstrated, achieved by coupling between a continuum of TE slab modes to a discrete TM mode of a silicon ridge to create a single sharp resonance.

10:00–11:30 Exhibit Open (10:00–15:00), Coffee Break (10:00–11:30), *Exhibit Halls 1–3*
Coffee Break Sponsored by COHERENT and THORLABS

10:15–12:00 Technology Transfer Program, *Exhibit Hall Theater I*

Meeting Room 211 A/B

CLEO: Applications & Technology

ATh1I • Radiative Cooling & Photovoltaics—Continued

ATh1I.6 • 09:30
Broadband Omni-resonant Enhancement in Near-Infrared Quantum-Efficiency of a Thin Film Amorphous Silicon Solar Cell, Massimo Villinger[1], Abbas Shiri[1], Soroush Shabahang[1], Magued B. Nasr[1], Chris Villinger[1], Ayman F. Abouraddy[1]; [1]*Univ. of Central Florida, USA.* By embedding an amorphous-silicon thin-film solar cell in an omni-resonant micro-cavity, we demonstrate a broadband boost in the near-infrared optical absorption and concomitant enhancement in the quantum efficiency.

ATh1I.7 • 09:45
Near Perfect Solar Energy Conversion for Vapor Generation, Youhai Liu[1], Haomin Song[1], Matthew H. Singer[1], Chenyu Li[1], Dengxin Ji[1], Lyu Zhou[1], Nan Zhang[1], Xie Zeng[1], Zongmin Bei[1], Zongfu Yu[2], Qiaoqiang Gan[1]; [1]*The State Univ. of New York at Buffalo, USA;* [2]*Univ. of Wisconsin, USA.* We demonstrate a strategy to realize ~100% efficiency for solar vapor generation by managing the energy flow, and to further enhance the evaporation by taking energy from the warmer environment.

Meeting Room 211 C/D

CLEO: Science & Innovations

STh1J • Nonlinear Photonics—Continued

STh1J.6 • 09:30
Saturable absorption of nonlinear graphene coated waveguides, Pierre Demongodin[1], Houssein El Dirani[2], Jérémy Lhuillier[1], Malik Kemiche[1], Thomas Wood[1], Ségolène Callard[1], Pedro Rojo-Romeo[1], Corrado Sciancalepore[2], Christian Grillet[1], Christelle Monat[1]; [1]*Institut des nanotechnologies de Lyon, France;* [2]*Optics and Photonics Division, CEA-LETI, France.* We investigate the saturable absorption of hybrid graphene/ silicon-nitride waveguides at telecom wavelengths. By measuring the power dependent transmission of picosecond and sub-picosecond pulses, we clarify the temporal dynamics of photo-excited carriers in graphene.

STh1J.7 • 09:45
Cavity Enhanced Trion Emission from a Bilayer MoTe2 on Silicon, Jianxing Zhang[1,2], Zizhao Zhong[1,2], Yongzhuo Li[1,2], Jiabin Feng[1,2], Lin Gan[1,2], Cunzheng Ning[1,3]; [1]*Dept. of Electronic Engineering, Tsinghua Univ., China;* [2]*Beijing National Research Center for Information Science and Technology, China;* [3]*School of Electrical, Computer, and Energy Engineering, Arizona State Univ., USA.* We study the coupling of a 2D silicon photonic crystal cavity with the trion emission of a bilayer MoTe2. Strong cavity enhanced emission of 3.4 times was observed, paving the way for low-energy photonic applications.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATh1K • Industrial Metrology & Remote Sensing—Continued

ATh1K.6 • 09:30
Laser-based Frequency Transfer over Underwater Link with Phase Compensation, Dong Hou[1], Guangkun Guo[1], Jiyuan Chen[1], Danian Zhang[1], Ke Liu[1], Fuyu Sun[2]; [1]*Univ. of Elect. Sci. and Tech. of China, China;* [2]*National Time Service Center, Chinese Academy of Science, China.* We demonstrate a laser-based transfer of radio-frequency signal with phase compensation over 5 m underwater link. The root-mean-square timing fluctuation of the transferred RF signal is about 2.3 ps within 5000 s.

ATh1K.7 • 09:45
Higher Order Bessel Beams Integrated in Time (HOBBIT) for Underwater Sensing and Metrology, Kaitlyn Morgan[1], Yuan Li[1], Wenzhe Li[1], Keith Miller[1], Joseph Watkins[1], Eric Johnson[1]; [1]*Clemson Univ., USA.* This paper introduces a novel platform for coherently coupled OAM modes that can be dynamically controlled at rates in excess of 100's kHz. Results are provided for a 512-QAM constellation composed of two OAM states.

Meeting Room 212 C/D

CLEO: Science & Innovations

STh1L • Hollow Core Fibers—Continued

STh1L.5 • 09:30
Nested-capillary anti-resonant silica fiber with mid-infrared transmission and very low bending sensitivity at 4000 nm, Mariusz Klimczak[1,2], Dominik Dobrakowski[1,2], Amar Nath Ghosh[3], Grzegorz Stepniewski[1], Dariusz Pysz[1], Thibaut Sylvestre[3], Ryszard Buczynski[2,1]; [1]*Inst of Electronic Materials Technology, Poland;* [2]*Faculty of Physics, Univ. of Warsaw, Poland;* [3]*Institut FEMTO-ST, CNRS, France.* Silica glass nested capillary anti-resonant fiber is reported. Transmission is measured with 150cm long sample over 1700-4200nm wavelengths, revealing a 3500-4200nm window. The fiber is bending insensitive down to 0.5cm radius over a full loop.

STh1L.6 • 09:45
Hollow-Core Conjoined-Tube Negative-Curvature Fiber with Loss approaching Rayleigh Scattering Limit of Silica, Shoufei Gao[1], Yingying Wang[1], Wei Ding[2], Yifeng Hong[1], Pu Wang[1]; [1]*Beijing Univ. of Technology, China;* [2]*Inst. of Physics, Chinese Academy of Science, China.* We report on a hollow-core conjoined-tube negative-curvature fiber with measured transmission losses of 2.7dB/km at 1150nm and 3.8dB/km at 680nm. The loss from 653 to 706 nm approaches the Rayleigh scattering limit of silica fiber.

10:00–11:30 Exhibit Open (10:00–15:00), Coffee Break (10:00–11:30), *Exhibit Halls 1–3*
Coffee Break Sponsored by COHERENT and THORLABS

10:15–12:00 Technology Transfer Program, *Exhibit Hall Theater I*

Marriott Salon I & II

CLEO: QELS-Fundamental Science

FTh1M • Ultrafast Processes in Gases & Solids—Continued

FTh1M.7 • 09:30
High Intensity 5th Harmonic Generation using CLBO, Siddharth Patankar[1], Steven T. Yang[1], Andrew J. Bayramian[1], Mark W. Bowers[1], Phillip S. Datte[1], George F. Swadling[1], Joel Stanley[1], Tracy S. Budge[1], James S. Ross[1]; [1]*Lawrence Livermore National Lab, USA.* We report results from frequency conversion experiments using a 1053 nm Nd:Glass laser system and a CLBO quintupler to generate fifth harmonic (211 nm) output. A peak 211 nm intensity of 0.4 GW/cm^2 was measured with a fundamental drive intensity of 2.25 GW/cm^2

FTh1M.8 • 09:45
Efficient 2-W Average Power 206nm Deep-UV Generation from 100-kHz Picosecond Pulses, Benjamin Willenberg[1], Fabian Brunner[1], Christopher Phillips[1], Ursula Keller[1]; [1]*ETH Zurich, Switzerland.* We present a 100-kHz all-solid-state deep-ultraviolet source delivering 206nm few-picosecond pulses with 2-W average power based on non-collinear sum frequency generation, which features high conversion efficiency by pulse front tilt matching and beam flattening.

Marriott Salon III

CLEO: Science & Innovations

STh1N • Sensing & Switching—Continued

STh1N.6 • 09:30
Low-loss integrated photonic switch using sub-wavelength patterned phase change material, Changming Wu[1], Heshan Yu[2], Huan Li[3], Xiaohang Zhang[2], Ichiro Takeuchi[2], Mo Li[1,3]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Washington, USA;* [2]*Dept. of Materials Science and Engineering, Univ. of Maryland, USA;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Minnesota, USA.* We demonstrate a 1×2 switch using phase Ge-Sb-Te (GST) integrated micro-ring resonator. The device achieves a low insertion loss of less than 1 dB in both output ports and can be switched photo-thermally and electro-thermally.

STh1N.7 • 09:45
DAC-less PAM4 Transmitter using Electro-optic Polymer Dual-drive Mach-Zehnder Modulator with Imbalanced Binary Driving Electronics , Guo-Wei Lu[1,2], Jianxun Hong[2], Hongbo Zhang[1,3], Feng Qiu[2], Shiyoshi Yokoyama[2]; [1]*Tokai Univ., Japan;* [2]*Kyushu Univ., Japan;* [3]*Chengdu Univ. of Information Technology, China.* We experimentally demonstrate a 20-Gb/s PAM4 transmitter using EO polymer dual-drive MZM with imbalanced binary driving electronics, eliminating the need of power-hungry DAC or linear drivers and featuring low power consumption and potentially low cost.

Marriott Salon IV

STh1O • Metasurfaces & Nanophotonic Materials—Continued

STh1O.6 • 09:30 Invited
Beating the Heat via Radiative Cooling: Tales of the Saharan Silver Ant, Comet Moth Silk Fibers, and Butterfly Wings, Nanfang Yu[1]; [1]*Columbia Univ., USA.* I will present the discovery of radiative cooling in living organisms and the development of bioinspired radiative-cooling technologies.

10:00–11:30 Exhibit Open (10:00–15:00), Coffee Break (10:00–11:30), *Exhibit Halls 1–3*
Coffee Break Sponsored by COHERENT and THORLABS

10:15–12:00 Technology Transfer Program, *Exhibit Hall Theater I*

11:30–13:00 JTh2A • Poster Session III and Lunch

JTh2A.1
Controlling Electron Quantum Paths for Generation of Circularly Polarized High-Order Harmonics by H_2^+ Subject to Tailored (ω, 2ω) Counter-Rotating Laser Fields, John T. Heslar[1], Dmitry A. Telnov[2], Shih-I Chu[1,3]; [1]*Dept. of Physics, National Taiwan Univ., Taiwan;* [2]*Dept. of Physics, St. Petersburg State Univ., Russia;* [3]*Dept. of Chemistry, Univ. of Kansas, USA.* We demonstrate the ability to control the electron recollisions giving three returns per one cycle of the fundamental frequency ω using tailored bichromatic (ω, 2ω) counter-rotating circularly polarized laser fields with a molecular target.

JTh2A.2
Low Energy Hollow Core Fiber Pulse Compression Using Molecular Gases, Elissa Haddad[1], Reza Safaei[1], Ojoon Kwon[1], Adrien Leblanc[1], Riccardo Piccoli[1], Young-Gyun Jeong[1], Heide Ibrahim[1], Bruno E. Schmidt[3], Roberto Morandotti[1,2], Luca Razzari[1], François Légaré[1], Philippe Lassonde[1]; [1]*INRS-EMT, Canada;* [2]*ITMO Univ., Russia;* [3]*Few-cycle Inc., Canada.* We show that hydrofluorocarbons can be used for efficient hollow core fiber pulse broadening. Fivefold compression, 45 fs down to ~9 fs, of low-energy titanium-sapphire laser pulses (~16 μJ) is achieved.

JTh2A.3
Phase-matched perturbative wave-mixing in XUV region, Khuong B. Dinh[1], Khoa Anh Tran[1], Peter Hannaford[1], Lap Dao[1]; [1]*Swinburne Univ. of Technology, Australia.* We demonstrate generation of phase-matched four-wave mixing frequencies in XUV region by using a driving field and two control fields. Our findings are promising to produce an XUV quasi-continuum for attosecond pulses synthesis.

JTh2A.4
Brunel harmonics generated from ionizing clusters by few-cycle laser pulses, Xiaohui Gao[1], Bonggu Shim[2], Michael Downer[3]; [1]*Shaoxing Univ., China;* [2]*Binghamton Univ., USA;* [3]*The Univ. of Texas at Austin, USA.* We theoretically demonstrate Brunel-type harmonic generation from ionizing nano-clusters irradiated by intense few-cycle laser pulses. Mie oscillations strongly blue-shift and enhance the internal field. The resulting subcycle ionization dynamics efficiently produce broadband VUV radiation.

JTh2A.5
Brunel harmonics in nanostructures, Ihar Babushkin[2,1], Liping Shi[2], Ayhan Demircan[2,3], Uwe Morgner[2,3], Milutin Kovacev[2]; [1]*Max-Born Inst., Germany;* [2]*Inst. of Quantum Optics, Univ. of Hannover, Germany;* [3]*Hannover Centre for optical Technologies, Germany.* Brunel harmonics appear in gases due to tunnel ionization of electrons in strong fields (without recollision with the cores). Here we extend this mechanism to nanostructures. The harmonics are affected by strong field gradients.

JTh2A.6
Optimization of RF Emission from Ultrashort Pulse Laser Filament via Genetic Algorithm and Deformable Mirror, Adrian Lucero[1], Alexander Englesbe[1], Jennifer Elle[1], Jinpu Lin[2], John Nees[2], Karl Krushelnick[2]; [1]*AFRL, USA;* [2]*Center for Ultrafast Optical Science, Univ. of Michigan, USA.* A genetic algorithm is used to drive a deformable mirror and optimize the RF emission from an ultrashort pulse plasma filament. The optimization process increases the plasma volume, linking plasma conductance to RF emission.

JTh2A.7
Measurements of Plasma Densities in Laser Filamentation in Solids at Various Wavelengths Spanning From Near and Mid Infrared, Garima C. Nagar[1], Dennis Dempsey[1], Bonggu Shim[1]; [1]*Binghamton Univ., USA.* We measure plasma densities in laser filamentation in fused silica using single-shot time-resolved interferometry when the filament driver wavelength is varied between 1.2 and 2.3 μm. The experimental results are compared with numerical simulations.

JTh2A.8
Towards Precision Measurements of Radiation Reaction, Yarden Sheffer[1], Morgan Lynch[1], Yaron Hadad[1], Ido Kaminer[1]; [1]*Technion - Israel Inst. of Technology, Israel.* We find the long-time dynamics of charges in electromagnetic fields, revealing that charge energy loss to radiation leads to counter-intuitive acceleration. Using this phenomenon, we propose a method to observe radiation reaction with weak fields.

JTh2A.9
Off-focus beam profile optimization for high-order harmonic generation, Jialin Li[1], Tianyi Guo[1], Jonathon White[1], Matthew Weidman[2], Yi Wu[1], Zenghu Chang[1]; [1]*Univ. of Central Florida, USA;* [2]*Max-Planck-Institut für Quantenoptik, Germany.* Customized wavefront correction was realized by an adaptive optics system in a high-energy femtosecond system to obtain smooth beam profiles far away from focal positions and boost the photon flux of high order harmonic generation.

JTh2A.10
Air-hole-type Valley Photonic Crystal Slab with Simple Triangular Lattice for Valley-contrasting Physics, Taiki Yoda[1,2], Masaya Notomi[1,2]; [1]*Tokyo Inst. of Technology, Japan;* [2]*NTT Basic Research Labs, Japan.* We theoretically propose a new scheme to realize a valley photonic crystal slab with simple triangular lattice. The eigenstates which are not originated from the Dirac cone can exhibit valley-contrasting physics by breaking inversion symmetry.

JTh2A.11
Control the Wave-front and Polarization of Light Simultaneously with High-efficiency Meta-surfaces, Dongyi Wang[1], Feifei Liu[1], Shulin Sun[1], Qiong He[1], Lei Zhou[1]; [1]*Fudan Univ., China.* We propose a generic approach for designing metasurfaces to efficiently control the wave-front and polarization of light simultaneously, and realized several meta-devices to verify the concept at near-infrared frequencies, which exhibit distinct light-manipulation capabilities.

JTh2A.12
Linking guided waves and surface waves via metasurface on terahertz-integrated platform, Ride Wang[1], Qiang Wu[1,2], Zixi Jia[1], Yaqing Zhang[1], Bin Zhang[3], Wei Cai[1,2], Jingjun Xu[1,2]; [1]*Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ., China;* [2]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China;* [3]*College of Science, Civil Aviation Univ. of China, China.* We implement the conversion from terahertz guided waves to surface waves via metasurface on lithium niobate subwavelength waveguide, providing a platform for thin-layer effective detection, which provides a more pronounced sensitivity than the normal interaction.

JTh2A.13
Withdrawn

JTh2A.14
Dual-wavelength Terahertz Metalens Based on Geometric Phase Metasurface, Tailei Wang[1], Hang Li[2], Rensheng Xie[1], Sensong An[2], Shouzheng Zhu[1], Guohua Zhai[1], Wei Guo[3], Hualiang Zhang[2], Jun Ding[1]; [1]*School of Information and Science Technology, East China Normal Univ., China;* [2]*ECE Dept., Univ. of Massachusetts Lowell, USA;* [3]*Physics and Applied Physics Dept., Univ. of Massachusetts Lowell, USA.* We proposed a novel dual-wavelength meta-atom, which could be used to independently modulate the geometric phase of the circularly polarized incident wave at two terahertz frequencies. A prototype dual-wavelength metalens has been designed and verified at the terahertz regime.

JTh2A.15
On-chip plasmon-induced transparency using a metastructure in THz regime, Wenjuan Zhao[1], Yao Lu[1], Qi Zhang[1], Jiwei Qi[1,2], Qiang Wu[1,2], Jingjun Xu[1,2]; [1]*The Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ., China;* [2]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China.* We experimentally and numerically demonstrated an investigation of plasmon-induced transparency using a meta-structure on a THz $LiNbO_3$ chip. A Rabi oscillation-like behavior at the transparency peak was obtained.

JTh2A.16
Control of slow-light effect in metamaterial-loaded Si waveguide, Makoto Tanaka[1], Tomo Amemiya[1], Satoshi Yamasaki[1], Hibiki Kagami[1], Keisuke Masuda[1], Nobu Nishiyama[1], Shigehisa Arai[1]; [1]*Tokyo Inst. of Technology, Japan.* We have demonstrated slow-light effect with the slow-down factor of >10 times in a metamaterial-loaded Si waveguide which can be easily integrated with other Si photonics devices, and proposed optically control method for that effect.

JTh2A.17
Optimal Single Metagrating for Robust Polarization Measurements, Nicolas Pedersen[1], Kai Wang[1], Shaun Lung[1], Andrey A. Sukhorukov[1]; [1]*Nonlinear Physics Centre, The Australian National Univ., Australia.* We formulate a new conceptual approach for full Stokes polarization measurement with a single metagrating, and develop novel design through advanced computational optimization of individual nano-resonator properties delivering robust operation even under strong fabrication inaccuracies.

JTh2A.18
On Speckle Intensity Correlations Over Object Position, Qiaoen Luo[1], Kevin J. Webb[1]; [1]*Purdue Univ., USA.* A general theory for intensity correlations over object position allows an arbitrary object to be imaged through an amount of scatter limited by detector noise. Applications include in vivo imaging, material inspection, and environmental sensing.

JTh2A.19
Spinning Radiation from Topological Insulators, Emroz Khan[1], Evgenii Narimanov[1]; [1]*Purdue Univ., USA.* We show that thermal radiation from a lossy topological insulator carries a nonzero average spin angular momentum.

JTh2A.20
Effect of Fabry-Perot Cavities on Concentration Quenching, Samantha R. Koutsares[1], Srujana Prayakarao[1], Devon Courtwright[1], Carl Bonner[1], M Noginov[1]; [1]*Norfolk State Univ., USA.* We show that concentration quenching of emission of dye molecules – an energy transfer to quenching centers – is inhibited in subwavelength Fabry-Perot cavities (or metal-insulator-metal, MIM, waveguides).

JTh2A.21
High Quality Resonances in Lithium Niobate Metasurfaces and Applications, Bofeng Gao[1], Mengxin Ren[1], Wei Wu[1], Hui Hu[2], Wei Cai[1], Jingjun Xu[1]; [1]*School of Physics and TEDA Applied Physics Inst., Nankai Univ., China;* [2]*School of Physics and Microelectronics, Shandong Univ., China.* We experimentally demonstrate the lithium niobate metasurfaces. High-quality structural resonances are observed in transmittance spectra. And such lithium niobate metasurfaces are proved to show vivid structural colors.

JTh2A.22
Impact of Surface Recombination and Doping on Optical Gain in Semiconductor Nanostructures, Jinal K. Tapar[1], Saurabh Kishen[1], Kaushik Nayak[1], Naresh K. Emani[1]; [1]*Indian Institue of Technology, Hyderabad, India.* We investigate the impact of surface recombination on optical gain, and show that the lasing threshold can be lowered by introducing strain and p-doping III-V material. This will make lasing in all-dielectric metasurfaces more practical.

11:30–13:00 JTh2A • Poster Session III and Lunch

JTh2A.23
Non-Paraxial Polarizer Model Based on Optically Anisotropic Media Theory, Site Zhang[1], Christian Hellmann[1,2], Frank Wyrowski[3]; [1]*LightTrans International UG, Germany;* [2]*Wyrowski Photonics UG, Germany;* [3]*Applied Computational Optics Group, Friedrich Schiller Univ. Jena, Germany.* We present an idealized polarizer model, based on the fields and modes in optically anisotropic media. The model is derived in the spatial-frequency domain, and the result is presented in a compact 2x2-matrix form.

JTh2A.24
Semi-Analytic Modeling of Chiral Metasurface Stacks, Jan Sperrhake[1], Manuel Decker[1], Matthias Falkner[1], Stefan Fasold[1], Thomas Kaiser[1], Isabelle Staude[1], Thomas Pertsch[1,2]; [1]*Inst. of Applied Physics, Germany;* [2]*Fraunhofer Institutit for Applied Optics and Precision Engineering, Germany.* We analyze the polarization response of a fabricated twisted nano-wire metasurface stack using a semi-analytic algorithm. This lifts the requirement for rigorous simulations when designing metasurface stacks with specific target functionalities.

JTh2A.25
Towards High Efficiency Dynamically Tunable Metaholograms, Isaac O. Oguntoye[1], Adam Ollanik[1], Yaping Ji[1], George Z. Hartfield[1], Matthew D. Escarra[1]; [1]*Physics and Engineering Physics, Tulane Univ., USA.* We propose a method for determination of nanoantenna transmitted phase for coupled, resonant nanoantennas in a heterogeneous array, necessary for design of metaholograms with ~90% optical efficiency. Progress toward fabrication of VO_2 nanoantennas is demonstrated.

JTh2A.26
Graphene-based Metamaterial Tunable Phase Modulator for Mid-Infrared Beam Steering, Cheng Shi[1,2], Isaac Luxmoore[1,2], Geoffrey Nash[1,2]; [1]*College of Engineer, Mathematics and Physics, Univ. of Exeter, UK;* [2]*EPSRC Centre for Doctoral Training in Electromagnetic Metamaterials,, Univ. of Exeter, UK.* We propose a design for graphene-based metamaterial tunable phase modulator, and investigate its feasibility in steering reflective beams in the mid-infrared regime. Simulations show that up to 45% steering efficiency can be achieved.

JTh2A.27
Light–to–heat conversion by optical absorption in a Si microring resonator, Toshiya Murai[1], Yuya Shoji[1], Tetsuya Mizumoto[1]; [1]*Tokyo Inst. of Technology, Japan.* An efficient light–to–heat conversion by optical absorption in a silicon microring resonator was demonstrated. We measured a wavelength shift due to thermo-optic effect and >300-K raise in temperature with light of 6.8 mW.

JTh2A.28
Design of Nonlinear Optical Ring Resonators, Ming Gong[1], Hui Wu[1]; [1]*Univ. of Rochester, USA.* We present a design methodology of nonlinear microring resonators based on iterations of matrix analysis. This new method is time/memory efficient and scalable, and can be applied to other nonlinear devices.

JTh2A.29
Visualization of a cavity-cavity coupling in a $LiNbO_3$ subwavelength waveguide at THz frequency, Qi Zhang[1], Deng Zhang[1], Jiwei Qi[1], Qiang Wu[1], Yao Lu[1], Hao Xiong[1], Wenjuan Zhao[1], Ride Wang[1], Jingjun Xu[1]; [1]*Nankai Univ., China.* We achieved a strong cavity-cavity coupling in a $LiNbO_3$ subwavelength waveguide at THz frequency. The wave confinement and radiation in the waveguide-cavity structure were visualized by a phase contrast imaging system.

JTh2A.30
Repair of pseudo time-reversal broken by topological phase transition in a photonic crystal slab, Yao Lu[1], Hao Xiong[1], Qiang Wu[1,2], Deng Zhang[1], Qi Zhang[1], Ride Wang[1], Wenjuan Zhao[1], Jingjun Xu[1,2]; [1]*The Key Lab of Weak-Light Nonlinear Photonics, Ministry of Education, TEDA Inst. of Applied Physics and School of Physics, Nankai Univ., China;* [2]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China.* We demonstrated a repair of pseudo time-reversal broken by topological phase transition in a photonic crystal slab. By changing the spatial structures, the unidirectional topological edge states transit to bidirectional trivial ones.

JTh2A.31
Germanium photodiodes on pyramidal textured surface by Metal-Assisted Chemical Etching, Munho Kim[2,1], Soongyu Yi[3], Jeong Dong Kim[2], Xin Yin[3], Jun Li[3], Jihye Bong[3], Dong Liu[3], Shih-Chia Liu[4], Alexander Kvit[3], Weidong Zhou[4], Xudong Wang[3], Zongfu Yu[3], Zhenqiang Ma[3], Xiuling Li[2]; [1]*Nanyang Technological Univ., Singapore;* [2]*ECE, Univ. of Illinois Urbana Champaign, USA;* [3]*Univ. of Wisconsin Madison, USA;* [4]*Univ. of Texas Arlington, USA.* We demonstrate a Ge photodiode on pyramidal textured surface by Metal-Assisted Chemical Etching (MacEtch) technique. This photodiode shows both reduced dark current and enhanced responsivity at near infrared (NIR) wavelength ranges.

JTh2A.32
Narrowband transmission filter based on silicon waveguide gratings, Tzu-Hsiang Yen[1], You-Cheng Lu[1], Yung-Jr Hung[1]; [1]*National Sun Yat-sen Univ., Taiwan.* We demonstrate that employing waveguide gratings in a Michelson interferometer is a much practical approach, as compared to Sagnac counterpart, to realize a narrowband transmission filter due to its shorter and relatively balanced connecting waveguides.

JTh2A.33
Regular-orbit engineered momentum transformation in the mixed phase space of an asymmetric microcavity, Likun Chen[1], Yan-Jun Qian[1], Qihuang Gong[1], Jan Wiersig[2], Yun-Feng Xiao[1]; [1]*Peking Univ., China;* [2]*Otto-von-Guericke-Universität, Germany.* We demonstrate the momentum transformation engineered by regular orbits in an asymmetric microcavity. It is found that the coupling efficiency from nanowaveguide to whispering gallery modes depends strongly on the initial momentum of light, illustrating localized structures in mixed phase space.

JTh2A.34
A Monolithically Integrated CMOS-MEMS Infrared Emitter with Graphene Oxide for Emission Enhancement, Nanxi Li[1], Hongye Yuan[2], Jifang Tao[1], Daw Don Cheam[1], Linfang Xu[1], Dan Zhao[2], Hong Cai[1], Navab Singh[1]; [1]*Inst. of Microelectronics, A*STAR, Singapore;* [2]*Dept. of Chemical and Biomolecular Engineering, National Univ. of Singapore, Singapore.* We demonstrate the emission enhancement of an integrated CMOS-MEMS infrared emitter by using graphene oxide (GO) coating, with an enhancement factor of >2. The characterizations of the GO and the MEMS emitter design are included.

JTh2A.35
Colloidal Quantum Dots for Near-Infrared Phototransistor with CMOS-Compatible Structure, Qi Wei Xu[1], Xihua Wang[1]; [1]*Univ. of Alberta, Canada.* We report a colloidal-quantum-dot photodetector for near-infrared detection. The detector has a CMOS-compatible structure with lower heat generation and interface treatment requirement. The device shows a responsivity of 5.9A/W at 1250 nanometers.

JTh2A.36
Free-Space Layered Sheet-Isolator, Rodion Kononchuk[1], Carl Pfeiffer[2], Nicholaos Limberopoulos[2], Igor Anisimov[2], Ilya Vitebskiy[2], Andrey Chabanov[1]; [1]*Physics & Astronomy, Univ. of Texas at San Antonio, USA;* [2]*Sensors Directorate, Air Force Research Lab, USA.* We introduce a multilayer acting as a free-space sheet-isolator with unlimited aperture, strong resonant transmission in a forward direction, and a possibility of broadband omnidirectional rejection of light incident on the opposite (back) side of the system.

JTh2A.37
Development of Longwave Infrared Tunable Notch Filters, Neelam Gupta[1], Mark S. Mirotznik[2]; [1]*US Army Research Lab, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Delaware, USA.* Spectrally tunable micro-engineered metamaterial notch filters operating from 8 to 12 micron were developed based on the guided mode resonance phenomenon using a subwavelength germanium grating and planar waveguide grown on a zinc selenide substrate.

JTh2A.38
Dynamically-tunable Plasmonic Devices Based on Phase Transition of Vanadium Dioxide, Ruwen Peng[1], Fang-Zhou Shu[1], Ren-Hao Fan[1], Mu Wang[1]; [1]*Nanjing Univ., China.* We have experimentally demonstrated several dynamically-tunable plasmonic devices based on phase transition of vanadium dioxide, which include dynamic color generators and dynamically switchable polarizers. The investigations can be applied in dynamic digital displays and imaging sensors.

JTh2A.39
Phase optimization of a silicon photonic two-dimensional electro-optic phased array, Michael R. Gehl[1], Galen Hoffman[1], Paul Davids[1], Andrew Starbuck[1], Christina Dallo[1], Zeb Barber[2], Emil Kadlec[2], R. Krishna Mohan[2], Stephen Crouch[2], Christopher Long[1]; [1]*Sandia National Labs Albuquerque, USA;* [2]*Blackmore Sensors and Analytics, Inc., USA.* Phase errors in large optical phased arrays degrade beam quality and must be actively corrected. Using a novel, low-power electro-optic design with matched pathlengths, we demonstrate simplified optimization and reduced sensitivity to wavelength and temperature.

JTh2A.40
Hybrid Photonic-Plasmonic Waveguides with Ultrathin TiN, Soham Saha[2,1], Aveek Dutta[2,1], Sarah Chowdhury[2,1], Alexander Kildishev[2,1], Vladimir M. Shalaev[2,1], Alexandra Boltasseva[2,1]; [1]*Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, USA.* We experimentally demonstrate hybrid photonic-plasmonic waveguides utilizing plasmonic TiN, and index mismatched substrate and superstrate. The design offers lower losses and tighter mode-confinement compared to previously reported long-range surface plasmon polariton waveguides using noble metals.

JTh2A.41
High-Performance Integrated Photonics in Thin Film Lithium Niobate Platform, Meisam Bahadori[1], Arunita Kar[1], Yansong Yang[1], Ali Meygoo Lavasani[1], Lynford L. Goddard[1], Songbin Gong[1]; [1]*Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA.* We present integrated photonics devices in thin film LN on insulator. The Q-factor of microrings is currently limited by the cavity loss and must be reduced by two orders of magnitude to hit 1,000,000 target.

JTh2A.42
High-Efficiency Silicon Mach-Zehnder Modulator with U-Shaped PN Junctions, Gangqiang Zhou[1], Linjie Zhou[1], Yuyao Guo[1], Lei Liu[2], Liangjun Lu[1], Jianping Chen[1]; [1]*Shanghai Jiaotong Univ., China;* [2]*Huawei Technologies Co. Ltd., China.* We demonstrate a silicon Mach-Zehnder modulator with U-shaped PN junctions to achieve a high modulation efficiency of 0.34 V•cm at 0 V bias. On-off key modulation is obtained at 32 Gb/s data rate.

JTh2A.43
Largely Tunable Plasmonic Antennas-on-Waveguide Directional Couplers with Deep Subwavelength Volume, Yuan Meng[1,2], Futai Hu[1], Yuanmu Yang[1,3], Qirong Xiao[1], Zhoutian Liu[1], Mali Gong[1]; [1]*State Key Lab of Precision Measurement Technology and Instruments, Tsinghua Univ., China;* [2]*Research Lab of Electronics, MIT, USA;* [3]*Sandia National Labs, USA.* Ultracompact versatile on-chip couplings are achieved in a largely tunable manner by synergy plasmonic nanoantennas with graphene. The operating wavelength can be tuned over 115 nm around 1.55 μm in deep-subwavelength volume with high directivity.

11:30–13:00 JTh2A • Poster Session III and Lunch

JTh2A.44
O-Band Add-Drop Filter in Bragg-Grating-Assisted Mach-Zehnder Interferometers for CWDM, Dominique J. Charron[1], Wei Shi[1]; [1]*Laval Univ., Canada.* We demonstrate a flat-top add-drop filter using silicon photonic Bragg gratings embedded in Mach-Zehnder interferometers. The device implemented using 193-nm lithography shows broad 3-dB bandwidth (>19 nm), low loss (2.3 dB) and high extinction ratio (> 32 dB).

JTh2A.45
ITO Mach-Zehnder Modulator on Si, Rubab Amin[1], Rishi Maiti[1], Caitlin Carfano[1], Zhizhen Ma[1], Mohammad H. Tahersima[1], Yigal Lilach[2], Dilan Ratnayake[2], Hamed Dalir[3], Volker J. Sorger[1]; [1]*Dept. of Electrical and Computer Engineering, The George Washington Univ., USA;* [2]*Nanofabrication and Imaging Center, George Washington Univ., USA;* [3]*Omega Optics, Inc., USA.* We demonstrate a monolithically integrated compact ITO electro-optic modulator in silicon photonics based on a Mach-Zehnder interferometer featuring a high-performance halfwave voltage and active device length product of $V_\pi L$ = 0.59 V-mm.

JTh2A.46
Adiabatic transitions between supersymmetric structures as a tool to design integrated photonic devices, Gerard Queraltó Isach[1], Verònica Ahufinger[1], Jordi Mompart[1]; [1]*Universitat Autonoma de Barcelona, Spain.* We introduce adiabatic transitions between supersymmetric structures as a systematic way to engineer efficient and robust integrated photonic devices by modifying the refractive index profile along the propagation direction.

JTh2A.47
Scaling of Mode Degeneracy and Image Fidelity in a Self-Imaging Optical Resonator, Albert Ryou[1], Shane Colburn[1], Alan Zhan[1], Arka Majumdar[1]; [1]*Univ. of Washington, USA.* Nonlinear optical processing of images in a miniature self-imaging cavity holds enormous potential for optical information processing and artificial neural networks. We analyze the inherent trade-off between the cavity size, image amplification, and image fidelity.

JTh2A.48
Electro-optic polymer surface-normal modulator using silicon high-contrast grating resonator, Makoto Ogasawara[1], Yuji Kosugi[1], Jiaqi Zhang[1], Yuki Okamoto[1], Yoshio Mita[1], Akira Otomo[2], Yoshiaki Nakano[1], Takuo Tanemura[1,3]; [1]*The Univ. of Tokyo, Japan;* [2]*National Inst. of Information and Communications Technology, Japan;* [3]*JST PRESTO, Japan.* A surface-normal optical modulator using electro-optic polymer embedded inside a 570-nm-thick silicon high-contrast-grating resonator is fabricated. With a voltage applied to silicon grating, we obtain >20% intensity modulation of the transmitted light at 30 MHz.

JTh2A.49
The role of surface passivation in integrated sub- bandgap on-chip silicon photodetectors, Rivka Gherabli[1], Meir Grajower[1], Joseph Shappir[1], Noa Mazurski[1], Uriel Levy[1]; [1]*Dept. of Applied physics, Hebrew Univ., Israel.* We demonstrate the role of passivation in silicon photonics photodetectors based on defect states operating in the sub bandgap regime. Upon passivation removal, higher responsivity is obtained alongside with loss reduction, surprisingly improving over time.

JTh2A.50
Slow cooking of SNAP microresonators, Gabriella Gardosi[1], Yong Yang[1], Misha Sumetsky[1]; [1]*Aston Univ., UK.* We demonstrate a SNAP microresonator permanently introduced at the silica microcapillary by multi-hour heating with hot water from the inside. The discovered effect is presumably caused by water-induced irreversible processes within the micron-scale silica thickness.

JTh2A.51
Producing OAM Information Carriers Using Micro-structured Spiral Phase Plates, Edgars Stegenburgs[1], Andrea Bertoncini[1], Abderrahmen Trichili[1], Mohd Sharizal Alias[1], Tien Khee Ng[1], Mohamed-Slim Alouini[1], Carlo Liberale[1], Boon S. Ooi[1]; [1]*King Abdullah Univ of Sci & Technology, Saudi Arabia.* We report on small foot-print spiral phase plates for orbital angular momentum (OAM) light beam generation used in free space communication. A modal decomposition process confirms high purity of the generated beams at.980-nm wavelength.

JTh2A.52
Extreme Sub-wavelength Optical Confinement in Nanostructured All-dielectric Silicon Waveguides, Nazmus Sakib[1], Judson Ryckman[1]; [1]*Clemson Univ., USA.* Novel approaches for the design of all-dielectric silicon waveguides featuring strong field enhancement and low mode areas are presented. Deeply subwavelength transverse characteristics, previously limited to nanoplasmonic waveguides, are predicted in an all-dielectric platform.

JTh2A.53
Ultrabroadband Integrated Photonic Filters for Waveguide-Based Sensing Systems, Nathan Tyndall[1], Todd H. Stievater[1], Dmitry Kozak[1], Marcel W. Pruessner[1], Scott Holmstrom[2], William Rabinovich[1]; [1]*US Naval Research Lab, USA;* [2]*Univ. of Tulsa, USA.* We describe the design and characterization of broadband, multi-stage waveguide lattice filters intended for integrated photonic sensing systems. The 8-stage filter provides 20 dB extinction at the filter resonance adjacent to a 190 nm passband.

JTh2A.54
Reconfigurable non-reciprocal acousto-optic modulator, Donggyu B. Sohn[1]; [1]*Univ. of Illinois, USA.* We experimentally demonstrate a reconfigurable non-reciprocal acousto-optic modulator. The directionality of mode conversion is controlled by adjusting the phase of a pair of standing acoustic waves.

JTh2A.55
Near-visible bright-soliton Kerr comb generation in dispersion-engineered lithium niobate coupled optical microresonators, Ali Eshaghian Dorche[1], Ali Eftekhar[1], Ali Adibi[1]; [1]*Georgia Inst. of Technology, USA.* We present an optimized, dispersion-engineered, air-clad, coupled lithium niobite optical-microresonator-based configuration for bright-soliton wideband (40 nm bandwidth at -70 dB window) Kerr-comb generation at the near-visible spectrum.

JTh2A.56
Bridge from Visible Light Communication to Telecommunication via Perovskite-Silicon Photonics, Ziwei Cheng[1], Anyi Mei[1], Zhao Cheng[1], Dingshan Gao[1], Sheng Li[1], Shuang Liu[1], Daiyu Li[1], Yaoguang Rong[1], Yue Hu[1], Hongwei Han[1], Jianji Dong[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, Huazhong Univ. of Science and Technology, China.* We propose and fabricate an all-passive, high-efficient, and coin-sized visible-to-telecom converter by hybrid packaging a perovskite detector with an integrated silicon photonic chip. The converter can convert visible light signals into telecommunication band with 200 kHz modulated rate.

JTh2A.57
High-Mobility Transparent Conducting Oxides for Compact Epsilon-Near-Zero Silicon Photonic Phase Modulators, Michael G. Wood[1], Isak Reines[1], Ting S. Luk[1,2], Darwin Serkland[1], Salvatore Campione[1]; [1]*Sandia National Labs, USA;* [2]*Center for Integrated Nanotechnologies, USA.* We numerically analyze the role of carrier mobility in transparent conducting oxides in epsilon-near-zero phase modulators. High-mobility materials such as cadmium oxide enable compact photonic phase modulators with a modulation figure of merit of >29 °/dB.

JTh2A.58
High signal-to-noise ratio for high-impedance-loaded nano-photodetector towards attojoule optical reception, Kengo Nozaki[1], Shinji Matsuo[1], Takuro Fujii[1], Koji Takeda[1], Eiichi Kuramochi[1], Akihiko Shinya[1], Masaya Notomi[1]; [1]*NTT Nanophotonics Center, Japan.* We demonstrate a signal-to-noise ratio for a photonic-crystal nano-photodetector loaded with 59-kΩ resistor revealing 30 dB higher than conventional photodetector thanks to thermal-noise suppression. Reception of ultralow optical energy of 74 aJ is theoretically expected.

JTh2A.59
RI Sensitivity of Tapered MCF Enhanced by Graphene Coating, HongXing Yu[2,1], Donglai Guo[2], LiJun Wu[2], Chi Li[2,1], Wenbin Hu[2]; [1]*Materials Science and Engineering, Wuhan Univ. of Technology, China;* [2]*National Engineering Lab for Fiber Optic Sensing Technology, Wuhan Univ. of Technology, China.* RI-sensitivity of a tapered MCF interferometer is investigated and enhanced by graphene coating. The microstructure with a graphene coating has achieved a RI-sensitivity of 12617.3 nm/RIU within the RI range of 1.4144 to 1.4159.

JTh2A.60
Heterogeneous Integration of Light-Emitting Transistors on Silicon for Hybrid Electronic-Photonic Logic Circuitry , John A. Carlson[1], John M. Dallesasse[1]; [1]*Electrical and Computer Engineering, Univ. of Illinois, USA.* An array of heterogeneously integrated light-emitting transistors is fabricated after an epitaxial transfer process bonds and interconnects active III-V photonic material onto a CMOS-compatible host wafer for the purposes of establishing a photonic logic network.

JTh2A.61
Temperature insensitive Mach-Zehnder interferometer on silicon nitride waveguide platform, Yu Li[1], Jiachen Li[1], Liwei Tang[1], Hongwei Chen[1], Sigang Yang[1], Minghua Chen[1]; [1]*Tsinghua Univ., China.* We demonstrate a temperature insensitive Mach-Zehnder interferometer (MZI) with low thermal sensitivity of 0.5 pm/K at 1560 nm. Across the wavelength range from 1525 nm to 1590 nm, the sensitivity is lower than 2 pm/K.

JTh2A.62
Optical NOR Gate Transistor Laser Integrated Circuit, Ardy Winoto[1], Junyi Qiu[1], Dufei Wu[1], Milton Feng[1]; [1]*Univ. of Illinois, USA.* An optical NOR gate has been demonstrated monolithically in a transistor laser structure using voltage modulation of the light output. The NOR gate can receive multiple optical input signals and produces the corresponding light output.

JTh2A.63
Athermal Operation of Multi-Section PIC, Gaurav Jain[2,1], Michael Wallace[2,1], M. Deseada Gutierrez Pascual[1], Robert J. McKenna[2], Frank Smyth[1], Jules Braddell[1], Prince M. Anandarajah[1], John Donegan[2]; [1]*Pilot Photonics, Ireland;* [2]*School of Physics, Trinity College Dublin, Ireland.* Energy-efficient athermal bias current procedures based on thermal-tuning is demonstrated for a PIC composed of 2 lasers in a master-slave configuration, achieving mode-hop free wavelength stability of 750 MHz over a temperature range 10-60 °C.

JTh2A.64
Polarization Insensitive Racetrack Ring Resonator Based on Subwavelength Grating Slot Waveguides, Xiaodong Wang[1], Yaqian Li[1], Xueling Quan[1], Xiulan Cheng[1]; [1]*Shanghai Jiao Tong Univ., China.* A polarization-insensitive racetrack ring resonator using subwavelength grating slot waveguides has been demonstrated. The device can realize polarization-insensitive in three free spectral ranges around 1539.345 nm. The extinction ratios are higher than 18 dB.

JTh2A.65
DC Kerr Effect and Limits for Silicon Photonic Modulators, Christian G. Bottenfield[1], Varghese A. Thomas[1], Stephen E. Ralph[1]; [1]*Georgia Inst. of Technology, USA.* We experimentally demonstrate the universal presence of the DC Kerr effect in silicon modulators and report performance trends and theoretical limits for DC Kerr effect optimization with implications for both digital and analog applications.

11:30–13:00 JTh2A • Poster Session III and Lunch

JTh2A.66
Study of Crystalline Defect Induced Optical Scattering Loss inside AlN Waveguides in UV-Visible Spectral Wavelengths, Hong Chen[1], Jingan Zhou[1], Houqiang Fu[1], Xuanqi Huang[1], Yuji Zhao[1]; [1]*Arizona State Univ., USA.* We study crystalline defect induced scattering loss inside AlN optical waveguides using volume current method. Result indicates that dislocation inside AlN contributes significant scattering loss in UV-visible spectrum wavelengths in certain geometries of waveguides.

JTh2A.67
Inverse Designed Cavity-Waveguide Couplers, Jinhie L. Skarda[1], Kiyoul Yang[1], Dries Vercruysse[1,2], Neil Sapra[1], Logan Su[1], Jelena Vuckovic[1]; [1]*Stanford Univ., USA;* [2]*KU Leuven, Belgium.* We experimentally demonstrate broadband and multiple wavelength cavity-waveguide coupling by optimizing the coupling region structure to produce a specified coupling spectrum. This work has applications in optical switching and nonlinear optics.

JTh2A.68
Hardware-Based Simulation of Optoelectronic Spiking Neuromorphic Computing Network, Junjie Hu[1], Kaiqi Zhang[1], S.J.Ben Yoo[1]; [1]*Electrical and Computer Engineering, Univ. of California Davis, USA.* We report an optoelectronic spiking neuromorphic computing network and propose a hardware-based simulation method for network design. The simulation result shows that the network can recognize simple patterns and patterns with noise.

JTh2A.69
Manifold-enhanced photon transportation in a chaotic microresonator, Yan-Jun Qian[1,4], Qi-Tao Cao[1,4], Shuai Wan[2], Chun-Hua Dong[2], Qihuang Gong[1,4], Qinghai Song[3], Yun-Feng Xiao[1,4]; [1]*School of Physics, Peking Univ., China;* [2]*Key Lab of Quantum Information, Univ. of Science and Technology of China, China;* [3]*Shenzhen Graduate School, Harbin Inst. of Technology, China;* [4]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China.* We study the photon transportation from chaotic to regular regions in an on-chip asymmetric microcavity. The manifold-enhanced fiber-cavity coupling is observed by controlling the initial position in phase space, holding potential for integrated photonics.

JTh2A.70
Multi-FSR On-Chip Optical Interconnects Using Silicon Nitride AWGR, Xian Xiao[1], Yu Zhang[1], Kaiqi Zhang[1], Roberto Proietti[1], S.J.Ben Yoo[1]; [1]*Univ. of California, Davis, USA.* We demonstrate multi-FSR 10 Gb/s on-chip optical interconnects using an 8×8 Si-LIONS monolithically integrated with a SiN cyclic AWGR and silicon photonic transceiver arrays.

JTh2A.71
Theoretical and experimental analysis on Ar Implantation-Induced Quantum Dot Intermixing for 1550 nm-Band Photonic Integrated Circuit, Atsushi Matsumoto[1], Yota Akashi[2], Shohei Isawa[2], Toshimasa Umezawa[1], Yuichi Matsushima[2], Katsuyuki Utakak[2]; [1]*National Inst of Information & Comm Tech, Japan;* [2]*Waseda Univ., Japan.* In this study, we theoretically and experimentally investigated an Ar ion implantation-induced quantum dot intermixing and its physical mechanism using photoluminescence and numerical simulations for the QD based monolithic PICs.

JTh2A.72
Two-dimensional Large-angle Scanning Optical Phased Array with Single Wavelength Beam, Pengfei Wang[1], Guangzhen Luo[1], Yajie Li[1], Mengqi Wang[1], Fangyuan Meng[1], Wenyu Yang[1], Hongyan Yu[1], Xuliang Zhou[1], Yejin Zhang[1], Jiaoqing Pan[1]; [1]*Inst. of Semiconductors, CAS, China.* A two-dimensional scanning optical phased array can easily achieve a circular scanning range of 51.84 °, 81.6% emission efficiency and 29.7dB back suppression ratio at 1550nm by adopting a high contrast grating (HCG) optical antenna.

JTh2A.73
A Switch-based Integrated 2D Beam-steering device for Lidar Application, Chao Li[1], Xianyi Cao[1], Kan Wu[1], Xinwan Li[1], Jianping Chen[1]; [1]*Shanghai Jiao Tong Univ., China.* A switch-based integrated two-dimensional beam-steering device is demonstrated on a silicon nitride platform at 1550nm. The device has O(logN) power consumption for N emitters, allows digital control and achieves 19 dB background suppression.

JTh2A.74
Silicon Grating Coupler for Mode Order Conversion, Iosif Demirtzioglou[1], Cosimo Lacava[1], Abdul Shakoor[1], Ali Khokhar[1], Yongmin Jung[1], David Thomson[1], Periklis Petropoulos[1]; [1]*Univ. of Southampton, UK.* A vertical silicon grating coupler that converts the propagation mode order at the waveguide-fiber interface was fabricated and characterized. Far-field intensity patterns are presented for different device configurations and the coupling efficiency is reported.

JTh2A.75
Broadband On-Chip Adiabatic-Coupling Polarization Mode Splitters in Lithium Niobate Waveguides, Yen-Hung Chen[1], Hung-Pin Chung[1], Chieh-Hsun Lee[1], Kuang-Hsu Huang[1], Song-Lin Yang[1], Kai Wang[2], Alexander Solntsev[3], Andrey A. Sukhorukov[2], Frank Setzpfandt[4]; [1]*National Central Univ., Taiwan;* [2]*The Australian National Univ., Australia;* [3]*Univ. of Technology Sydney, Australia;* [4]*Friedrich-Schiller-Universität Jena, Germany.* We report the first broadband (>120 nm at >97% splitting efficiency for both polarization modes) polarization mode-splitter in $LiNbO_3$ adiabatic light-passage configuration. This device can facilitate the on-chip implementation of pump-filtered, broadband tunable Bell-state generators.

JTh2A.76
CMOS Foundry DRC-Conforming Extended Cladding Modulated Integrated Bragg Grating Filters, Gareeyasee Saha[1], Christian G. Bottenfield[1], Patrick S. Goley[1], John D. Cressler[1], Stephen E. Ralph[1]; [1]*Electrical and Computer Engineering, Georgia Inst. of Technology, USA.* We demonstrate a CMOS-compatible extended cladding modulated integrated Bragg Grating filter, while meeting strict DRC requirements of SiPh foundries. A narrow bandwidth of 2.1nm on the phase-shifted portion and 29.2dBm extinction ratio is measured.

JTh2A.77
DPSK-based 65536-ary Ciphering for Secure Optical Communications, Takahiro Kodama[1], Gabriella Cincotti[2]; [1]*Univ. of Yamanashi, Japan;* [2]*Engineering Dept., Univ. Roma Tre, Italy.* We propose and demonstrate a secure DPSK-based multi-dimensional 2^{16}-ary block ciphering system using a multiport encoder/decoder for secure optical fiber transmission. The proposed scheme presents a very high physical-level confidentiality.

JTh2A.78
Crosstalk Tracing in Weakly-Coupled Short-Reach Mode-Division Multiplexing Optical Networks with Deep Learning, Ruijie Luo[1], Nan Hua[1], Yanlong Li[1], Zelin Zheng[1], Zhizhen Zhong[1], Xiaoping Zheng[1], Bingkun Zhou[1]; [1]*Tsinghua Univ., China.* We propose a crosstalk tracing method using deep neural networks for weakly-coupled MDM optical networks. Results show that over 95% tracing accuracy is achieved and the impact of time consistency in data collection is revealed.

JTh2A.79
CW-probe-less OOK and BPSK to QPSK optical modulation format conversion and SSMF transmission, Takahiro Kodama[1], Tatsuya Miyazaki[1], Koki Arai[1]; [1]*Univ. of Yamanashi, Japan.* A pair of OOK and BPSK to QPSK format conversion with XPM and its 50km SSMF transmission of the optically converted QPSK are experimentally demonstrated. A HNLF input power tolerance of OOK is also reported.

JTh2A.80
Joint OSNR, Skew, ROF Monitoring of Coherent Channel using Eye Diagram Measurement and Deep Learning, Yiwen Zhang[3], Yongxiong Ren[1], Zhi Wang[3], Bo Liu[3], Hao Zhang[3], Si-Ao Li[3], Yuxi Fang[3], Hao Huang[1], Changjing Bao[1], Zhongqi Pan[2], Yang Yue[3]; [1]*Dept. of Electrical Engineering, Univ. of Southern California, USA;* [2]*Dept. of Electrical & Computer Engineering, Univ. of Louisiana, USA;* [3]*Inst. of Modern Optics, Nankai Univ., China.* CNN-based deep learning is used to monitor coherent channel performance with eye diagram measurement. For 32GBd-QPSK signals, 99.57% prediction accuracy is achieved for 15 to 40dB OSNR, -15 to 15ps skew, 0.05 to 1 ROF.

JTh2A.81
In-band nonlinear distortion measurements for highly linear wideband optical links, Farzad Mokhtari-Koushyar[1], McKay B. Bradford[2], Thien-An Nguyen[2], Monireh Moayedi Pour Fard[2], Sriram Vishwanath[1]; [1]*ECE, Univ. of Texas at Austin, USA;* [2]*Photonics Group, GenXComm Inc, USA.* A distortion measurement method is presented for highly-linear wideband optical links. By notching a spur-free region inside signal band before the link and isolating the notch after the link, SFDR of 147.6 dBm/Hz is demonstrated.

JTh2A.82
Demonstration of all-optical clock recovery from NRZ-PM-QPSK and PM-16QAM signals, Manas Srivastava[1], Lakshmi Narayanan Venkatasubramani[1], Balaji Srinivasan[1], Deepa Venkitesh[1]; [1]*Indian Inst. of Technology, Madras, India.* We demonstrate all-optical clock recovery from optical NRZ-PM-QPSK and NRZ-PM-16QAM data at 10 Gbaud after 60 km fiber propagation, through injection-locking of an Erbium-doped fiber laser.

JTh2A.83
Influence of Polarization Transformation in Phase Conjugation of PM-QPSK in Nonlinear SOAs, Aneesh Sobhanan[1], Lakshmi Narayanan Venkatasubramani [1], R David Koilpillai[1], Deepa Venkitesh[1]; [1]*Indian Inst. of Technology, Madras, India.* Polarization insensitive phase conjugation generation is experimentally demonstrated using a single pump in a nonlinear SOA for 10 GBaud PM-QPSK data. The influence of polarization transformation properties specific to signal-pump detuning conditions are established.

JTh2A.84
Remote detection of uranium with filament ablation spectroscopy, Lauren A. Finney[1], Patrick J. Skrodzki[1], Milos Burger[1], John Nees[1], Igor Jovanovic[1]; [1]*Univ. of Michigan, USA.* We demonstrate that femtosecond filaments can efficiently excite metallic uranium over distances on the order of 10 meters, and that characteristic uranium atomic and molecular signatures can be simultaneously detected in seconds.

JTh2A.85
Polarization-insensitive amplitude-modulated CW LiDAR, Chao Zhang[1], Neisei Hayashi[1], Sze Y. Set[1], Shinji Yamashita[1]; [1]*Research Center for Advanced Science and Technology, The Univ. of Tokyo, Japan.* We propose a 3D laser scanner having depolarization function which suppresses inherent fading by >20 dB at a maximum. To our knowledge, this is the first report of versatile fading removal for 3D laser scanners.

JTh2A.86
Quantitative TLC-SERS Sensing of Allergen from Seafood, Yong Zhao[1,2], Ailing Tan[1,2], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*Yanshan Univ., China.* We report a quantitative analysis method using thin layer chromatograph in tandem with surface-Enhanced Raman scattering sensing to detect seafood allergen, which is enabled by the principal component analysis and partial least squares regression.

11:30–13:00 JTh2A • Poster Session III and Lunch

JTh2A.87

Integrating Cavity Enhanced Raman Spectroscopy of Trace Gases and Bulk Compounds, Thomas Z. Moore[1], Vladislav Yakovlev[2,3], John Mason[2], Edward Fry[2], Dawson Nodurft[2], Vincent Tedford[2], Kristin Favela[1]; *[1]Southwest Research Inst., USA; [2]Physics, Texas A&M Univ., USA; [3]Biomedical Engineering, Texas A&M Univ., USA.* The Raman spectra of trace gases and bulk compounds are measured using an integrating cavity enhanced Raman spectroscopy technique. The technique utilizes an integrating cavity formed from fumed silica providing significant Raman signal enhancement.

JTh2A.88

Optoelectronic biosensing in graphene driven fiber resonators with single-molecule sensitivity and selectivity, Baicheng Yao[1], Zhongxu Cao[1], Yu Wu[1], Teng Tan[1], Chenye Qin[1], Yuanfu Chen[1], Yuan Gong[1], Zhenda Xie[2], Chee Wei Wong[3], Yun Jiang Rao[1]; *[1]Univ of Electronic Science & Tech China, China; [2]Nanjing Univ., China; [3]Univ. of California, Los Angeles, USA.* By implementing partially-reduced graphene oxide in fiber-calibrated Fabry-Perot resonators, we demonstrate a biosensing platform. By measuring the functionalized FRET and the intermode heterodyne interference, we achieve single-molecule sensitivity and selectivity for multiple target detection.

JTh2A.89

Dual comb-linked cavity ring-down spectroscopy, Weipeng Zhang[1], Xinyi Chen[1], Haoyun Wei[1], Yan Li[1]; *[1]Tsinghua Univ., China.* A dual comb-linked scheme for cavity ring-down is presented, which maintained both an excellent stability of the cavity length and accurate measurement of the probing frequency. Several absorption lines of oxygen were measured.

JTh2A.90

An FBG-based High-resolution Temperature Sensor through Measuring the Beat Frequency of Single-frequency Ring Fiber Laser, Liangcheng Duan[1], Wei Shi[1], Haiwei Zhang[1,2], Xianchao Yang[1], Ying Lu[1], Jianquan Yao[1]; *[1]Tianjin Univ., China; [2]Tianjin Univ. of Technology, China.* A high-resolution temperature sensor based on narrow-linewidth (<1 kHz) single-frequency ring fiber laser was investigated using optical heterodyne spectroscopy technology. Temperature resolution of ~5×10^{-3} °C was achieved in our experiment.

JTh2A.91

Nuclear recoil spectroscopy in an optical trap, Alexander Malyzhenkov[1,2]; *[1]Los Alamos National Lab, USA; [2]The Paul Scherrer Inst., Switzerland.* We discuss the conditions that allow the observation of nuclear decay recoil for small particles levitated in an optical trap. We report on trapping uranium oxide particles at ambient conditions as a first experimental step.

JTh2A.92

Characterization of small-scale contortions on a physical-surface using a distributed optical-fiber sensor, Raja Ahmad[1], Wing Ko[1], Kenneth S. Feder[1], Paul S. Westbrook[1]; *[1]OFS Labs, USA.* We use spatially continuous measurements of the Bragg-wavelength of a grating in an offset-core fiber to measure continuous, sub-millimeter length-scale variations on the surface of a corrugated metal surface.

JTh2A.93

2.3µm Wavelength Single Photon LIDAR with Superconducting Nanowire Detectors, Gregor G. Taylor[1], Dmitry Morozov[1], Nathan R. Gemmell[2], Kleanthis Erotokritou[1], Robert H. Hadfield[1]; *[1]Univ. of Glasgow, UK; [2]Univ. of Sussex, UK.* A superconducting nanowire single photon detector system designed for 2.3µm wavelength deployed into a single photon light detection and ranging setup. This wavelength takes advantage of lower solar flux and less atmospheric absorption.

JTh2A.94

Plasmonic stripes integrated in a silicon nitride Mach Zehnder Interferometer for high sensitivity refractometric sensors, Athanasios Manolis[1], Evangelia Chatzianagnostou[1], George Dabos[1], Nikos Pleros[1], Bartos Chmielak[2], Anna Lena Giesecke[2], Caroline Porschatis[2], Pietr Cegielski[2], Laurent Markey[3], Jean-Claude Weeber[3], Alain Dereux[3], Dimitris Tsiokos[1,4]; *[1]Dept. of Informatics - Center for Interdisciplinary Research and Innovation, Aristotle Univ. of Thessaloniki, Greece, Greece; [2]AMO GmbH, Advanced Microelectronic Center Aachen (AMICA), Otto-Blumenthal-Strasse, Aachen, Germany, Germany; [3]Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB), CNRS UMR 6303, Université de Bourgogne Franche-Comté, 21078, Dijon, France, France; [4]bialoom Ltd, 72, 28th Octovriou Avenue, Office 301, Engomi, 2414 Nicosia, Cyprus, Cyprus.* We demonstrate an interferometric plasmo-photonic sensor based on Si_3N_4 photonic waveguides and gold Surface Plasmon Polariton waveguides. The proposed approach exhibits bulk sensitivity up to 1930 nm/RIU, holding promise for compact and ultra-sensitive interferometric sensing devices.

JTh2A.95

Hydrostatic Pressure Response of Mo Coated Etched Fiber Bragg Grating Sensor in Side-Hole Packaging, Suneetha Sebastian[1]; *[1]Instrumentation and Applied Physics, Indian Inst. of Science, India.* We demonstrate side-hole packaged; nanolayer Molybdenum (Mo) coated etched Fiber Bragg Grating (eFBG) as hydrostatic pressure sensor. Pressure sensitivity enhancement of nearly 2000 times is observed with such a simple, ruggedized and packaged sensor system.

JTh2A.96

CO_2 Detection with Si Slot Waveguide Ring Resonators toward On-chip Specific Gas Sensing, Yuki Tomono[1], Hayato Hoshi[1], Hiromasa Shimizu[1]; *[1]Tokyo Univ. of Agri. and Tech., Japan.* We fabricated a Si slot waveguide ring resonator detecting CO_2 with RI difference of 1.5×10^{-4} and sensitivity of 3×10^{2} nm/RIU. The device satisfies both detecting capability and compatibility with biolayer toward on-chip specific gas sensing.

JTh2A.97

Microring Resonator Biosensor Sensitivity Enhancement through Ring-down Interferogramsµ, Shih-Hsiang Hsu[1], Feng-Chang Chien[1], Chou-Yun Hsu[1]; *[1]National Taiwan Univ of Science & Tech, Taiwan.* The microring resonator biosensor sensitivity is enhanced by round-trip ring-down waveforms interrogated with two-staged Mach–Zehnder interferograms through optical low-coherence interferometry. The sensitivity and resolution on influenza DNA demonstrate 49 µm/µM and 1.53 nM, respectively.

JTh2A.98

Omni-Resonant Micro-Cavity Toggling between Active and Passive Imaging, Soroush Shabahang[1,2], Ali K. Jahromi[1], Kenneth L. Schepler[1], Ayman Abouraddy[1]; *[1]Univ. of Central Florida, USA; [2]Harvard Medical School, Massachusetts General Hospital, USA.* We have demonstrated an experimental scheme for incorporating two distinct functionalities in the same optical system: narrowband resonant filtering and broadband omni-resonant transmission. Both functionalities are realized in-line in an imaging configuration.

JTh2A.99

A 20-GHz Optoelectronic Oscillator based on an Electroabsorption Modulated Laser, Siyu Zhao[1], Juanjuan Yan[1], Zheng Zheng[1]; *[1]Beihang Univ., China.* An optoelectronic oscillator based on an electroabsorption modulated laser is experimentally demonstrated. The phase noise is measured to be -110.2dBc/Hz at 10kHz offset from the carrier when the oscillation frequency is 20GHz.

JTh2A.100

Single-Mode Fiber Based Pulsed-Optical Timing Link with Few-Femtosecond Precision in SwissFEL, Kemal Shafak[1], Haynes Pak Hay Cheng[1], Anan Dai[1], Maik Kaiser[2], Vladimir Arsov[2], Andrej Berlin[1], Erwin Cano[1], Wahid Nasimzada[1], Mathias Neuhaus[1], Philipp Schiepel[1], Stephan Hunziker[2], Franz Kärtner[3]; *[1]Cycle GmbH, Germany; [2]Paul Scherrer Institut, Switzerland; [3]Center for Free Electron Laser Science, Deutsches Elektronen Synchrotron, Germany.* We present results from a pulsed-optical timing link using single-mode fiber components installed in SwissFEL. The system shows 2.6-fs RMS timing jitter in [1 MHz - 20 µHz] and presents a versatile alternative to polarization-maintaining version.

JTh2A.101

Combination of Lock-in Detection with Dual-Comb Spectroscopy, Hidenori Koresawa[1,2], Kyuki Shibuya[1,2], Akifumi Asahara[3,2], Takeo Minamikawa[1,2], Kaoru Minoshima[3,2], Takeshi Yasui[1,2]; *[1]Tokushima Univ., Japan; [2]JST, ERATO MINOSHIMA Intelligent Optical Synthesizer, Japan; [3]The Univ. of Electro-Communications, Japan.* We present a method to extract an arbitrary mode in a mode-resolved optical-frequency-comb spectrum by introducing a lock-in detection in dual-comb spectroscopy. The proposed method reduces net measurement time due to no fast-Fourier-transform calculation.

JTh2A.102

Overcoming the Diffraction Limit of Optical Microscopes For Measuring Tapered Optical Fibers, Abderrahim Azzoune[1], Philippe Delaye[1], Sylvie Lebrun[1], Maha Bouhadida[1], Gilles Pauliat[1]; *[1]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris-Saclay, France.* We describe a technique that allows increasing the resolution of optical microscopes for nanofiber measurements. We demonstrated it by measuring the diameter of tapered fibers for radii ranging from 0.2 to 1.5 µm.

JTh2A.103

Asymmetric fiber delay line interferometer based noise measurement platform for Er: fiber optical frequency combs, Haochen Tian[1], Wenkai Yang[1], Dohyeon Kwon[2], Runmin Li[1], Youjian Song[1], Jungwon Kim[2], Minglie Hu[1]; *[1]Tianjin Univ., China; [2]South Korea Advanced Inst. of Science and Technology, South Korea (the Republic of).* Frequency noise spectrum for comb-line spacing, carrier envelope offset frequency and optical comb lines are characterized simultaneously in an Er:fiber optical frequency comb, enabling the study of inherent noise correlations.

JTh2A.104

Locking CW Laser to Ultra-stable Optical Frequency Comb by Feed-forward Method, Xiaodong Shao[1,3], Hainian Han[1], Yabei Su[1,2], Huibo Wang[1,2], Ziyue Zhang[1,3], Shaobo Fang[1], Guoqing Chang[1], Zhiyi Wei[1,3]; *[1]Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China; [2]School of Physics and Optoelectronics Engineering, Xidian Univ., China; [3]Univ. of Chinese Academy of Science, China.* We report a precision feed-forward locking between a 1064 nm CW laser and an ultra-stable frequency comb. The relative linewidth of the 1064nm CW laser is 1.14 mHz and the stability reaches 1.5×10^{-17}/s.

JTh2A.105

Polarization and phase shifting interferometry, Sergej Rothau[1], Klaus Mantel[2], Norbert Lindlein[1]; *[1]Friedrich-Alexander-Univ., Germany; [2]Max Planck Inst. for the Science of Light, Germany.* A novel interferometric approach for a full-field and simultaneous measurement of the phase and the polarization state of a light wave is introduced. The same procedure can be used for simultaneous analysis of the phase transmission and the polarization properties of a specimen.

JTh2A.106

Time-Resolved Dual Frequency Comb Phase Spectroscopy of Laser-Induced Plasmas, Reagan R. Weeks[1], Yu Zhang[2,1], Caroline Lecaplain[1], Jeremy Yeak[3], Sivanandan S. Harilal[4], Mark C. Phillips[4], R. J. Jones[1]; *[1]College of Optical Sciences, Univ. of Arizona, USA; [2]Physics, Univ. of Arizona, USA; [3]Opticslah, USA; [4]Pacific Northwest National Lab, USA.* We present the first results using time-resolved dual-comb phase spectroscopy in a laser-induced plasma. It can allow for simultaneous plasma characterization as well as multi-species detection and plasma characterization.

11:30–13:00 JTh2A • Poster Session III and Lunch

JTh2A.107
Continuously-chirped guided mode resonance filter for low-cost near-infrared spectroscopic applications, Chuan-Ci Yin[1], Chia-Wei Kao[1], Chia-Wei Huang[1], Yung-Jr Hung[1]; [1]*National Sun Yat-sen Univ., Taiwan.* We demonstrate a continuously period-chirped Ta_2O_5-based guided mode resonance filter to discriminate telecom o-band wavelengths with a filter linewidth of 0.743 nm, thus enables on-chip spectroscopy for near-infrared light in a low-cost manner.

JTh2A.108
Three-Beam Interferometry for Dynamic and Low-Signal Measurements, Adam Ollanik[1], George Z. Hartfield[1], Matthew D. Escarra[1]; [1]*Tulane Univ., USA.* We present an interferometer for the characterization of dynamic optical materials and metasurfaces. A three-beam method provides robust measurements despite unavoidable drift. Measurements are demonstrated with a phase-change material, ultra-thin materials, and a dielectric metasurface.

JTh2A.109
Direct comb multi-heterodyne spectroscopy for rapid detection of trace gases, Jaehyun Lee[1], Keunwoo Lee[1], Jaewon Yang[1], Young-Jin Kim[2], Seung-Woo Kim[1]; [1]*KAIST, South Korea (the Republic of);* [2]*School of Mechanical and Aerospace Engineering, NTU, Singapore.* We perform high sensitive spectroscopic measurements by combining a single probe comb with multiple cw lasers so as to produce strong RF multi-heterodyne spectra for rapid detection of different trace gases.

JTh2A.110
A nonlinear interferometer using a designable Raman-resonant four-wave-mixing process, Jian Zheng[1], Masayuki Katsuragawa[1,2]; [1]*Graduate School of Informatics and Engineering, Univ. of Electro-Communications, 1-5-1, Chofugaoka, Chofu, Tokyo 182-8585,Japan, Japan;* [2]*JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, 4-1-8, Honcho, Kawaguchi, Saitama 332-0012, Japan, Japan.* A new kind of nonlinear interferometer is proposed based on the arbitrary designable Raman-resonant four-wave-mixing process.

JTh2A.111
Cavity-Enhanced Direct Optical Frequency Comb Spectroscopy with Tooth-Width Limited Resolution, Dominik Charczun[1], Grzegorz Kowzan[1], Akiko Nishiyama[1], Przemyslaw Staniszewski[1], Agata Cygan[1], Daniel Lisak[1], Ryszard S. Trawinski[1], Piotr Maslowski[1]; [1]*Inst. of Physics, Nicolaus Copernicus Univ. in Torun, Poland.* We present a multimodal spectroscopic method employing optical frequency combs, optical cavities and Fourier-transform spectrometry. It allows fast and broadband measurements of both absorption and dispersion spectra as well as of dispersion and reflectivity of mirrors.

JTh2A.112
Optical frequency stability transfer using a single-branch Er:fiber frequency comb, Felix Rohde[1], Thomas Puppe[1], Rafal Wilk[1], Burghard Lipphardt[2], Uwe Sterr[2], Erik Benkler[2]; [1]*TOPTICA Photonics AG, Germany;* [2]*Physikalisch-Technische Bundesanstalt, Germany.* We report on the frequency transfer from an ultrastable laser at 1542 nm to a clock laser at 935 nm using a single-branch commercial Er:fiber optical frequency comb.

JTh2A.113
Cost-efficient thermal tuning and stabilization system for fiber-based optical frequency combs, Aleksander Gluszek[1], Arkadiusz Hudzikowski[1], Jaroslaw Sotor[1], Grzegorz J. Sobon[1]; [1]*Wroclaw Univ. of Science and Technology, Poland.* We present the design of a compact, low-cost thermal stabilization system for mode-locked fiber lasers without using Peltier modules. Repetition rate tuning of 0.85 kHz per 1°C was achieved in a 100 MHz frequency comb.

JTh2A.114
High Brightness Broadband Infrared Light Source, from 0.3 to 20 Microns, Matthew J. Partlow[1], Ron Collins[1], Alex Culter[1], Debbie Gustafson[1], Steve Horne[1], Don McDaniel[1]; [1]*Energetiq Technology, Inc., USA.* Development of broadband, high brightness Laser-Driven Light Sources (LDLS™) covering the infrared spectrum (2 – 20 µm) is described. Radiance performance is compared to that of a ceramic broadband thermal emitter light source.

JTh2A.115
Orbital-Angular-Momentum Azimuthal Phase-Shift-Keying via Digital Holography Through Turbulent Media, Raymond Lopez-Rios[1], Usman A. Javid[1], Qiang Lin[1]; [1]*Inst. of Optics, Univ. of Rochester, USA.* We report a digital holographic technique for retrieving the OAM azimuthal phase difference of coherent beams co-propagating through turbulence. Experimental results suggest that OAM phase-shift keying schemes are feasible for large-bandwidth free-space optical communication.

JTh2A.116
The CLONETS – Clock Network Services Strategy and innovation for clock services over optical-fibre networks, Josef Vojtech[1]; [1]*CESNET, Czechia.* Methods for long-distance time and frequency transfer over optical fibers have demonstrated excellent performances. CLONETS is a EU funded action intended to facilitate the vision of a sustainable, pan-European optical fiber network for precise time and frequency reference dissemination.

JTh2A.117
Boosting Second-Harmonic Generation in Nonlinear Metasurfaces with Bound States in the Continuum, Kirill Koshelev[1,2], Andrey Bogdanov[2], Yuri S. Kivshar[1,2]; [1]*Australian National Univ., Australia;* [2]*Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia.* We apply the concept of bound states in the continuum to nonlinear metasurfaces with a broken in-plane symmetry and realize high-Q resonances boosting dramatically the SHG efficiency via a smart asymmetry engineering.

JTh2A.118
Flat Lenses for Ultra-lightweight Long-wave-Infrared Broadband Imaging, Monjurul Meem[1], Sourangsu Banerji[1], Apratim Majumder[1], Berardi Sensale Rodriguez[1], Rajesh Menon[1]; [1]*Univ. of Utah, USA.* We demonstrate the design and experiments for chromatic aberration rectified, high NA, polarization insensitive, diffractive flat lenses operating in the LWIR (8mm to 12mm) regime.

JTh2A.119
High Q-Factor All-Dielectric Metasurface Based on Bound States in the Continuum, Shaimaa Azzam[1], Krishnakali Chaudhuri[1], Vladimir M. Shalaev[1], Alexandra Boltasseva[1], Alexander Kildishev[1]; [1]*Purdue Univ., USA.* We propose a realization of bound states in the continuum (BICs) with metasurfaces. Resonances with theoretically-infinite quality-factors can be achieved in the BIC regime and with up to a few thousand in the near-BIC.

12:30–14:00 Pizza Lunch, *Exhibit Halls 1-3*

Executive Ballroom 210A

14:00–16:00
FTh3A • Gateways to Quantum Information Processing
Presider: Peter Mosley; Univ. of Bath, UK

FTh3A.1 • 14:00
Repeated Multi-Qubit Readout and Feedback in a Mixed-Species Trapped-Ion Register, Karan Mehta[1], Vlad Negnevitsky[1], Matteo Marinelli[1], Hsiang-Yu Lo[1], Christa Flühmann[1], Jonathan Home[1]; *[1]ETH Zurich, Switzerland.* We measure the parity of two beryllium ion qubits by mapping the relevant operator onto an ancillary calcium qubit, utilizing multi-species entangling gates. Repeated measurement and feedback cycles allow preparation and stabilization of parity subspaces and Bell states.

FTh3A.2 • 14:15
Quantum Computing using MAGIC with Trapped Atomic Ions, Christof Wunderlich[1], Ivan Boldin[1], Hans Briegel[2,3], Vedran Dunjko[2,4], Elham Esteki[1], Nicolai Friis[5,2], Gouri Giri[1], Timm Gloger[1], Michael Johanning[1], Delia Kaufmann[1], Peter Kaufmann[1], Alexander Kraft[1], Bogdan Okhrimenko[1], Moritz Porst[1], Theeraphot Sriarunothai[1], Sabine Wölk[1,2]; *[1]Universität Siegen, Germany; [2]Univ. of Innsbruck, Austria; [3]Univ. of Konstanz, Germany; [4]Max Planck Inst. for Quantum Optics, Germany; [5]Austrain Academy of Sciences, Austria.* A programmable quantum computer based on trapped ions interacting via magnetic gradient induced coupling (MAGIC) together with elements for scaling quantum computing – transport of ions and a novel trap for 2D ion arrays – are reported.

FTh3A.3 • 14:30
Variational Quantum Unsampling on a Programmable Nanophotonic Processor, Jacques Carolan[1], Masoud Mosheni[2], Jonathan Olson[3], Mihika Prabhu[1], Changchen Chen[1], Darius Bunandar[1], Nicholas C. Harris[4], Franco N. Wong[1], Michael Hochberg[5], Seth Lloyd[1], Dirk R. Englund[1]; *[1]MIT, USA; [2]Google Quantum AI Lab, USA; [3]Zapata Computing Inc., USA; [4]Lightmatter, USA; [5]Elenion Technologies, USA.* We introduce the Variational Quantum Unsampling (VQU) protocol, a nonlinear quantum neural network approach for verification and inference of near-term quantum circuits outputs. We experimentally demonstrate this protocol on a quantum photonic processor.

Executive Ballroom 210B

14:00–16:00
FTh3B • Tailorable Phenomena in Optical Fibers
Presider: To Be Announced

FTh3B.1 • 14:00 Tutorial
The Curious Properties of Twisted Photonic Crystal Fibres, Philip S. Russell[1,2]; *[1]Max Planck Inst. Science of Light, Germany; [2]Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* Helically twisted hollow and solid core photonic crystal fibers display many curious properties: perfect circular birefringence, circular dichroism, birefringence between modes of equal and opposite azimuthal order, and guidance even when there is no core.

Philip Russell is a Director at the Max-Planck Institute for the Science of Light in Erlangen, Germany. A fellow of the Royal Society and The Optical Society (OSA), he specializes in scientific applications of photonic crystal fibre, which he first proposed in 1991. He was the 2015 OSA President.

Executive Ballroom 210C

14:00–16:00
FTh3C • Emission & Detection of Thermal Radiation
Presider: Peter Catrysse, Stanford Univ., USA

FTh3C.1 • 14:00
Near-Field and Far-Field Thermal Emission of individual subwavelength-sized resonators, Yannick De Wilde[1], Claire Li[1,2], Joris Doumouro[1], Valentina Krachmalnicoff[1], Patrick Bouchon[2], Julien Jaeck[2], Nathalie Bardou[3], Karl Joulain[4], Riad Haidar[2], Houssem Kallel[4]; *[1]Institut Langevin, ESPCI Paris, PSL Univ., CNRS,, France; [2]DOTA, ONERA, Université Paris-Saclay, France; [3]Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Sud, Université Paris-Saclay, France; [4]3 Institut Pprime, CNRS, Université de Poitiers, ISAE-ENSMA, France.* We combine spatial modulation FTIR spectroscopy with TRSTM measurements to characterize the thermal emission of plasmonic antennas and silica rods. The fundamental mode of MIM nanoantennas with silica dielectric layer is excited at multiple wavelengths.

FTh3C.2 • 14:15
Machine-learning-assisted topology optimization for highly efficient thermal emitter design, Zhaxylyk A. Kudyshev[1], Alexander Kildishev[1], Vladimir M. Shalaev[1], Alexandra Boltasseva[1]; *[1]Purdue Univ., USA.* We coupled generative adversarial network with topology optimization for efficient thermal emitter design development. The proposed method can generate highly efficient metasurface designs with a non-trivial topology for efficient spectral control of thermal blackbody radiation.

FTh3C.3 • 14:30 Invited
Broadband Nanophotonic Control of Low-temperature Thermal Radiation, Aaswath Raman[1]; *[1]Univ. of Pennsylvania, USA.* We highlight new nanophotonic strategies for controlling and tuning the spectral and angular response of broadband, room-temperature thermal radiation in the long-wave infrared. We also introduce novel applications and capabilities enabled by this control, including for energy efficiency.

Executive Ballroom 210D

14:00–16:00
FTh3D • Quantum Photonics: Generation & Manipulation
Presider: Raphael Pooser; Oak Ridge Natinoal Labs, USA

FTh3D.1 • 14:00 Tutorial
Quantum Communications, Prem Kumar[1]; *[1]Northwestern Univ., USA.* After comparing and contrasting quantum communications with the traditional classical communications, I will focus on device technologies and review their current state-of-the-art for interconnecting distant quantum data nodes in a quantum network of the future.

Prem Kumar is professor of information technology at Northwestern University. His current research focus is on quantum photonic devices and their applications in quantum communications and networking. During 2013-17, Dr. Kumar was a Program Manager at DARPA. He is a Fellow of the OSA, APS, IEEE, IoP (U.K.), AAAS, and SPIE.

Executive Ballroom 210E | Executive Ballroom 210F | Executive Ballroom 210G | Executive Ballroom 210H

CLEO: Science & Innovations

14:00–16:00
STh3E • Ultrafast Parametric Sources I
Presider: Gabrielle Thomas M Squared Lasers, Scotland

STh3E.1 • 14:00 Invited
High-Average-Power Mid-Infrared Sources for Spectroscopy and Strong-Field Physics at 100 kHz., Nicolas Forget[1], Nicolas Thiré[1], Raman Maksimenka[1], Yoann Pertot[1], Olivier Albert[1], Balint Kiss[2], Eric Cormier[2], Károly Osvay[2]; [1]*FASTLITE, France;* [2]*ELI-HU, Hungary.* We demonstrate a 100-kHz, 15-W, OPCPA delivering 4-cycle (38 fs) pulses at ~3.2 μm. Over 8h, a pulse-to-pulse energy stability <0.7% rms and a single-shot CEP noise of 65 mrad RMS is reported.

STh3E.2 • 14:30
Sub-Two-Cycle High-Average-Power Pulses at 2.5 μm, Justinas Pupeikis[1], Nicolas Bigler[1], Stefan Hrisafov[1], Lukas Gallmann[1], Christopher Phillips[1], Ursula Keller[1]; [1]*ETH Zurich, Switzerland.* We present a 12.6 W optical parametric chirped-pulse amplifier (OPCPA) generating pulses at 100 kHz centered at 2.5 μm. With a novel pulse shaping scheme, the pulses were compressed to 14.4 fs (1.6 cycles).

14:00–16:00
STh3F • Nonlinear THz Phenomena
Presider: Edbert Sie, Stanford University, USA

STh3F.1 • 14:00 Tutorial
Terahertz photonics of graphene - from nonlinear absorption to high harmonics generation, Dmitry Turchinovich[1]; [1]*Universität Bielefeld, Germany.* Graphene is possibly the most nonlinear electronic material discovered to date. We demonstrate strongly nonlinear THz conductivity of graphene leading to extremely efficient THz high harmonics generation, and explain it using a simple thermodynamic model resting on basic conservation laws.

Dmitry Turchinovich is a full professor of experimental physics at Bielefeld University. His research interests are ultrafast condensed matter physics and general ultrafast science. He received his PhD from the University of Freiburg in 2004. Prior to his current appointment, he held faculty positions at the Technical University of Denmark, MPI for Polymer Research, and the University of Duisburg-Essen. Professor Turchinovich is OSA Senior Member and recipient of EU Career Integration Grant.

14:00–16:00
STh3G • Precision Timing & Optical Time Transfer
Presider: Andrew Metcalf; AFRL, USA

STh3G.1 • 14:00
Free-Space Optical Time Transfer Between an Atomic Frequency Standard and a Simple Optical Clock, Matthew S. Bigelow[1], Rafe Guidice[1], Kyle Martin[1], Andrew J. Metcalf[2], Nathan D. Lemke[3]; [1]*Applied Technology Associates, USA;* [2]*Space Vehicles Directorate, Air Force Research Lab, USA;* [3]*Bethel Univ., USA.* We present a tabletop demonstration of free-space time-frequency transfer from a compact optical rubidium atomic frequency standard to stabilize a clock based on a fiber laser locked to fiber-delay line compared with a cavity-stabilized laser.

STh3G.2 • 14:15
Optical two-way time transfer with enhanced SNR for longer distance free-space links, Jennifer L. Ellis[1], Isaac H. Khader[1], Martha I. Bodine[1], William C. Swann[1], Sarah A. Stevenson[1], Emily D. Hannah[1], Laura C. Sinclair[1], Nathan R. Newbury[1], Jean-Daniel Deschênes[2]; [1]*NIST, USA;* [2]*Consultation OctoSig Inc., Canada.* We explore the tradeoffs in signal-to-noise ratio and timing performance for comb-based optical two-way time transfer with a goal of future very long distance free-space links between optical clocks.

STh3G.3 • 14:30
Preliminary Measurements for Three-Node Optical Two-Way Time and Frequency Transfer, Sarah A. Stevenson[1,2], Paritosh Manurkar[1,2], Martha I. Bodine[1], William C. Swann[1], Jennifer L. Ellis[1], Isaac H. Khader[1,2], Emily D. Hannah[1,2], Michael Cermak[1], Jean-Daniel Deschênes[3], Nathan R. Newbury[1], Laura C. Sinclair[1]; [1]*National Inst. of Standards and Technology, USA;* [2]*Univ. of Colorado Boulder, USA;* [3]*Octosig Consulting Inc., Canada.* Here we present preliminary results for a three-node network using optical two-way time transfer. We discuss the design and initial testing of a fieldable remote node, which shows performance consistent with a previous Lab system.

14:00–16:00
STh3H • Modulation & Switching
Presider: Ali Adibi; Georgia Institute of Technology, USA

STh3H.1 • 14:00
Efficient Pure Phase Optical Modulator Based on Strongly Over-Coupled Resonators, Guozhen Liang[1], Heqing Huang[1], Sajan Shrestha[1], Ipshita Datta[2], Michal Lipson[2], Nanfang Yu[1]; [1]*Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA;* [2]*Dept. of Electrical Engineering, Columbia Univ., USA.* We demonstrate that large pure optical phase modulation is possible in resonators operated in the strongly over-coupling regime, which suggests efficient phase modulators with high-speed operation, small footprint, low insertion loss, and low power consumption.

STh3H.2 • 14:15
Silicon Photonic Modulator Using Coupled Bragg Grating Resonators in a Mach-Zehnder structure, Omid Jafari[1], Wei Shi[1], Sophie Larochelle[1]; [1]*Laval Univ., Canada.* We demonstrate a silicon modulator enhanced by Bragg-grating resonators. The compact modulator (130-μm phase shifters) with $V_\pi \times L$= 0.25 V.cm has a 32-GHz EO bandwidth consuming only 80 fJ/bit at 10 Gbit/s.

STh3H.3 • 14:30
Low-Voltage-Swing Electro-Absorption Modulator by High Mobility Conductive Oxide on Silicon Waveguide, Qian Gao[1], Erwen Li[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* We present a 5μm length silicon electro-absorption modulator using high mobility indium oxide gate. The device operates at 100 nm optical bandwidth and 2.5 GHz dynamic modulation, which requires only 2V voltage swing.

Meeting Room 211 A/B

CLEO: Applications & Technology

14:00–16:00
ATh3I • A&T Topical Review on Silicon Photonics I
Presider: To Be Announced

ATh3I.1 • 14:00 Invited
Monolithic Silicon Optoelectronics with Standard CMOS Processes, Alex Wright[1]; [1]*Ayar Labs, USA.* Abstract not available.

ATh3I.2 • 14:30
Low loss and robust photonic packaging using fusion splicing, Juniyali Nauriyal[1], Meiting Song[1], Raymond Yu[1], Jaime Cardenas[1]; [1]*Univ. of Rochester, USA.* We show a novel photonic packaging method for permanent optical edge coupling between a fiber and chip using fusion splicing. We demonstrate minimum loss of 1.0dB per-facet with 0.6dB penalty over 160nm bandwidth around 1550nm.

Meeting Room 211 C/D

CLEO: Science & Innovations

14:00–16:00
STh3J • Emerging Nonlinear Platforms
Presider: Katia Gallo, KTH, Sweden

STh3J.1 • 14:00
Near-Visible Microresonator-Based Soliton Combs, Yun Zhao[1], Xingchen Ji[1,2], Bok Young Kim[1], Prathamesh Donvalkar[1,2], Jae K. Jang[1], Chaitanya Joshi[1,2], Mengjie Yu[1,2], Renato Domeneguetti[3], Felippe A. Barbosa[1], Paulo Nussenzveig[3], Yoshitomo Okawachi[1], Michal Lipson[1], Alexander Gaeta[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA;* [3]*Universidade de São Paulo, Brazil.* We experimentally demonstrate soliton mode-locked Kerr comb generation at near-visible wavelengths in a silicon nitride microresonator. We achieve the shortest wavelength to-date for mode-locked Kerr combs through dispersion engineering of a higher-order mode.

STh3J.2 • 14:15
Chaos-assisted cross-band microcombs, Hao-Jing Chen[1], Qing-Xin Ji[1], Qihuang Gong[1], Xu Yi[2], Yun-Feng Xiao[1]; [1]*School of Physics, Peking Univ., China;* [2]*Dept. of Electrical and Computer Engineering, and Dept. of Physics, Univ. of Virginia, USA.* We demonstrate microcombs in a deformed microcavity with emission from 450 nm to 2000 nm. The cross-band intracavity emission is harnessed to a nanowaveguide through the chaotic-assisted momentum transformation.

STh3J.3 • 14:30
Thermal Noise and Laser Cooling of Kerr-Microresonator Frequency Combs, Tara E. Drake[1], Jordan Stone[1,2], Travis C. Briles[1,2], Scott B. Papp[1,2]; [1]*NIST, USA;* [2]*Univ. of Colorado, USA.* We present measurements and analysis of the fundamental noise in Kerr-microresonator frequency combs due to finite temperature. By exploiting the thermo-optic locking effect, we reduce the effect of these thermally-driven fluctuations on the comb coherence.

Meeting Room 212 A/B

CLEO: Applications & Technology

14:00–16:00
ATh3K • Trace Species Sensing
Presider: Brian Simonds, National Institute of Standards and Technology, USA

ATh3K.1 • 14:00
The NAOMI GAZL multispecies differential absorption lidar: realization and testing on the TADI gas leak simulation facility, Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Antoine Godard[1], Vincent Lebat[1], Nicolas Tanguy[1], Cédric Blanchard[1], Xavier Watremez[2], Dominique Dubucq[2], Stéphanie Doz[3], Pierre-Yves Foucher[3], Myriam Raybaut[1]; [1]*DPHY, ONERA, Université Paris Saclay, France;* [2]*TOTAL, France;* [3]*ONERA/DOTA, Université de Toulouse, France.* We report on a differential absorption lidar, designed for remote detection of CH_4 and CO_2, based on a single-frequency 1.57-1.65 µm parametric oscillator/amplifier system. The lidar is tested on a controlled gas release facility.

ATh3K.2 • 14:15
Spectroscopy With Frequency Comb-Locked Optical Swept Synthesizer, Riccardo Gotti[1], Thomas Puppe[2], Yuriy Mayzlin[2], Julian Robinson-Tait[2], Szymon Wojtewicz[3], davide gatti[1], Bidoor Al Saif[4], marco lamperti[1], Paolo Laporta[1], Felix Rohde[2], Rafal Wilk[2], Patrick Leisching[2], William Kaenders[2], Marco Marangoni[1]; [1]*Physics, Politecnico di Milano, Italy;* [2]*Toptica Photonics AG, Germany;* [3]*Nicolaus Copernicus Univ., Poland;* [4]*King Abdullah Univ. for Science and Technology, Saudi Arabia.* A CW-laser phase-locked to an endlessly shifting frequency comb enables spectroscopic investigations with metrological quality and high sensitivity at speeds beyond 1 THz/s over frequency ranges that can be set on demand over 10 THz.

ATh3K.3 • 14:30 Invited
Exploiting Coherence for Trace Explosives Detection, David S. Moore[1], Shawn McGrane[1], Margo Greenfield[1], Kathryn (Katie) Brown[1]; [1]*Los Alamos National Lab, USA.* This talk will present concepts and results applying coherent control techniques to enhance the detection capabilities of currently deployed methods for trace detection of explosives in the real world.

Meeting Room 212 C/D

CLEO: Science & Innovations

14:00–16:00
STh3L • Multi-Mode Fiber Phenomena I
Presider: To Be Announced

STh3L.1 • 14:00
High-power multi transverse modes random fiber laser with considerably low spatial coherence, Rui Ma[1,2], Jia Qi Li[1], Jia Yu Guo[1], Han Wu[1], Hua Hui Zhang[1], Bo Hu[1], Yun Jiang Rao[1], Wei Li Zhang[1]; [1]*Univ of Electronic Science & Tech China, China;* [2]*Aston Inst. of Photonic Technologies, UK.* A high-power multi-transverse modes random fiber laser is realized with ~56 W output power and considerably low speckle contrast ~0.01 through the combination of a master oscillator power-amplifier and a segment of step-index multimode fiber.

STh3L.2 • 14:15
Robust Cell Imaging through Anderson Localizing Optical Fiber Based on Deep Learning, Jian Zhao[1], Yangyang Sun[1], Jose Enrique Antonio-Lopez[1], Rodrigo Amezcua Correa[1], Shuo Pang[1], Axel Schülzgen[1]; [1]*CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA.* Robust artifact-free cell imaging is demonstrated by combing a meter-long Anderson localizing optical fiber with deep learning using incoherent illumination. The tolerance to fiber bending can reach ~3 degrees for high-fidelity cell-image transport.

STh3L.3 • 14:30 Invited
Novel Concepts for Sensing, Imaging and Mode Generation in Fibres Using High-Index Glass, Heike Ebendorff-Heidepriem[1], Stephen Warren-Smith[1], Jiawen Li[1], Erik Schartner[1], Hong Ji[1], Yinlan Ruan[1], Dongbi Bai[2], Brant Gibson[2], Tanya Monro[3], Robert McLaughlin[1]; [1]*Univ. of Adelaide, Australia;* [2]*RMIT Univ., Australia;* [3]*Univ. of South Australia, Australia.* The high refractive index of heavy metal oxide glasses combined with their low processing temperatures enables new fiber concepts such as enhanced imaging core density, stable doughnut beam delivery, miniaturized imaging+sensing and intrinsic magnetic sensitivity.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

14:00–16:00
FTh3M • Metasurfaces
Presider: Rajesh Menon; Univ. of Utah, USA

FTh3M.1 • 14:00
Computational Holographic Camera with a Dielectric Metasurface Diffuser, Hyounghan Kwon[1], Ehsan Arbabi[1], Seyedeh M. Kamali[1], MohammadSadegh Faraji-Dana[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA.* We experimentally demonstrate computational complex optical field imaging by a metasurface diffuser and the speckle-correlation scattering matrix method. Thus we show that the metasurface diffuser can outperform conventional scattering media in context of computational imaging.

FTh3M.2 • 14:15
Dielectric metasurfaces performing all-analog computing, Concetto Eugenio Andrea Cordaro[1], Hoyeong Kwon[2], Dimitrios Sounas[2,3], Femius Koenderink[1], Albert Polman[1], Andrea Alù[2,4]; [1]*AMOLF, Netherlands;* [2]*Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA;* [3]*Electrical and Computer Engineering, Wayne State Univ., USA;* [4]*CUNY Advanced Science Research Center, USA.* We present experimental results on metasurfaces capable of performing analog image processing. Specifically, we show designs for 1st and 2nd order spatial differentiation enabling low power and real-time edge detection.

FTh3M.3 • 14:30
Metalens for light field imaging, Cheng Hung Chu[2], Mu Ku Chen[1], Hsin Yu Kuo[1], Ren Jie Lin[1], Shuming Wang[3], Vin-Cent Su[4], Tsung Lin Chung[1], Jia-Wern Chen[1], Yi-Teng Huang[1], Pin Chieh Wu[2], Tao Li[3], Shining Zhu[3], Din Ping Tsai[2,1]; [1]*National Taiwan Univ., Taiwan;* [2]*Academia Sinica, Taiwan;* [3]*College of Engineering and Applied Sciences, School of Physics, China;* [4]*National United Univ., Taiwan.* We use a 60 × 60 dielectric achromatic metalens array to capture multidimensional optical information including both image and depth. The scene can be reconstructed slice by slice from a series of rendered full-color images.

Marriott
Salon III

CLEO: Science & Innovations

14:00–16:00
STh3N • Hybrid Integration with Si Photonics
Presider: Beibei Zeng; Corning Inc., USA

STh3N.1 • 14:00
Heterogeneously Integrated Low-power-consumption Semiconductor Optical Amplifier on Si Platform, Tatsurou Hiraki[1], Takuma Aihara[1], Koji Takeda[1], Takuro Fujii[1], Tai Tsuchizawa[1], Takaaki Kakitsuka[1], Shinji Matsuo[1]; [1]*NTT Device Technology Labs, Japan.* A membrane semiconductor optical amplifier heterogeneously integrated with SiN waveguides on SiO_2/Si substrate exhibits 10-dB on-chip gain with 13-mA bias current. Clear eye openings are obtained with 10- and 28-Gbit/s NRZ signals.

STh3N.2 • 14:15
50Gb/s CVD Graphene-Insulator-Graphene Electro-Absorption Modulator on Si waveguide, Vito Sorianello[1], Simone Marconi[2,1], Marco Angelo Giambra[1], Vaidotas Miseikis[1,3], Alberto Montanaro[1], Camilla Coletti[3,4], Marco Romagnoli[1]; [1]*Photonic Networks and Technologies Lab – CNIT, Italy;* [2]*Tecip Inst. - Scuola Superiore Sant'Anna, Italy;* [3]*Graphene Labs, Istituto Italiano di Tecnologia, Italy;* [4]*Center for Nanotechnology Innovation @NEST, Istituto Italiano di Tecnologia, Italy.* We demonstrate a non-return to zero optical modulation at 50Gb/s with a CVD grown Graphene-Insulator-Graphene electro-absorption modulator integrated on a Si photonic waveguide. The device exhibits a 3dB electro-optical bandwidth of 30GHz.

STh3N.3 • 14:30
Asymmetric graphene-on-silicon nitride waveguide photodetector towards fast speed and high responsivity, Yun Gao[1], Hon Ki Tsang[1], Chester Shu[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong.* We demonstrate a 6-μm long asymmetric graphene-on-silicon nitride waveguide photodetector with a measured electro-optic bandwidth of 38 GHz and a responsivity of 13 mA/W at 1550 nm. Carrier dynamics in the photodetector are also analyzed.

Marriott
Salon IV

14:00–16:00
STh3O • 2D Materials
Presider: Matthew Escarra; Tulane University, USA

STh3O.1 • 14:00
External Quantum Efficiency of Monolayer $MoTe_2$ based Near-Infrared Light Emitting Diodes, Jiabin Feng[1], Yongzhuo Li[1], Song Fu[1], Jianxing Zhang[1], Zizhao Zhong[1], Hao Sun[1], Lin Gan[1], Cunzheng Ning[1,2]; [1]*Tsinghua Univ., China;* [2]*Arizona State Univ., USA.* We demonstrated a monolayer $MoTe_2$ based near-IR light emitting diode on SiO_2/Si substrate and determined for the first time the external quantum efficiency of the device in the range of 10^{-4} ~ 5×10^{-3} at 5~300K.

STh3O.2 • 14:15
Birefringence and Dispersion Analysis of Hexagonal Boron Nitride (h-BN), Yoonhyuk Rah[1], Yeonghoon Jin[1], Sejeong Kim[2], Kyoungsik Yu[1]; [1]*KAIST, South Korea (the Republic of);* [2]*Univ. of Technology Sydney, Australia.* h-BN is a promising material for photonics and electronics applications, but its optical properties are not well known. We observe normal dispersion, near 0 extinction coefficient and birefringence of exfoliated h-BN in the visible wavelengths.

STh3O.3 • 14:30
Direct Growth of Large-area Graphene by Cross-linked Parylene Graphitization toward Photodetection, Yibo Dong[1], Chuantong Cheng[2], Chen Xu[1], Xurui Mao[2], Yiyang Xie[1], Guanzhong Pan[1], Qiuhua Wang[1], Jie Sun[3]; [1]*Beijing Univ. of Technology, China;* [2]*Inst. of Semiconductor, Chinese Academy of Sciences, China;* [3]*Fuzhou Univ., China.* Large area uniform graphene was directly grown on insulating substrate by cross-linked Parylene graphitization. The as-grown graphene was used for the fabrication of graphene-Si Schottky junction photodetector with a responsivity of 275.9 mA/W.

Thursday, 14:00–16:00

FTh3A • Gateways to Quantum Information Processing—Continued

FTh3A.4 • 14:45
Deterministic Two-photon Controlled-phase Gate Enabled by Induced pi-phase Shift in Photonic Molecule Generations, Zihao Chen[1], Yao Zhou[1], Jung-Tsung Shen[1]; [1]*Washington Univ. in St. Louis, USA.* We propose a novel deterministic two-photon controlled-phase gate scheme enabled by a nonlinear pi-phase shift imprinted during photonic molecule generations, which serves as a vital building block for scalable photon-based quantum computing network.

FTh3A.5 • 15:00
Error-Disturbance Tradeoff in Sequential Quantum Measurements, Ya-Li Mao[1], Zhi-Hao Ma[2], Rui-Bo Jin[3], Qi-Chao Sun[1], Shao-Ming Fei[4,5], Qiang Zhang[1], Jingyun Fan[1], Jian-Wei Pan[1]; [1]*Univ. of Science and Technology of China, China;* [2]*Shanghai Jiao Tong Univ., China;* [3]*Wuhan Inst. of Technology, China;* [4]*Capital Normal Univ., China;* [5]*Max-Planck-Inst. for Mathematics in the Sciences, Germany.* We derive a state-dependent error-disturbance tradeoff based on statistical distance in the sequential measurements of a pair of noncommutative observables and experimentally verify the relation with a photonic qubit system.

FTh3A.6 • 15:15
Subatomic Many-Body Physics Simulations on a Quantum Frequency Processor, Hsuan-Hao Lu[1], Natalie Klco[2], Joseph M. Lukens[3], Titus D. Morris[4,3], Aaina Bansal[5], Andreas Ekstrom[6], Gaute Hagen[4,5], Thomas Papenbrock[5,4], Andrew M. Weiner[1], Martin J. Savage[2], Pavel Lougovski[3]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Inst. for Nuclear Theory,, Univ. of Washington, USA;* [3]*Quantum Information Science Group, Oak Ridge National Lab, USA;* [4]*Physics Division, Oak Ridge National Lab, USA;* [5]*Dept. of Physics and Astronomy, Univ. of Tennessee, USA;* [6]*Dept. of Physics, Chalmers Univ. of Technology, Sweden.* We demonstrate a photonic quantum simulation on a quantum frequency processor, computing the effective interaction potential between composite particles in the Schwinger model and determining the binding energies of three nuclei (^{3}H, ^{3}He, and ^{4}He).

FTh3A.7 • 15:30 Invited
Limitations on the Use of the Heisenberg Picture in Quantum Information Applications, James D. Franson[1]; [1]*Univ. of Maryland Baltimore County, USA.* We show that the Heisenberg operator produced by a unitary transformation cannot be used as the input to a second transformation. The experimental implications of this will be illustrated using several examples in quantum optics.

FTh3B • Tailorable Phenomena in Optical Fibers—Continued

FTh3B.2 • 15:00
Entropic Response of Polarization Dynamics in Nonlinear Multimode Optical Systems, Fan Wu[1], Absar U. Hassan[1], Demetrios N. Christodoulides[1]; [1]*Univ. of Central Florida, USA.* We show that the Hamiltonian "energy" of a nonlinear multimoded optical system involving two circular polarizations always flows from a hotter to a colder arrangement– as expected from the second law of thermodynamics.

FTh3B.3 • 15:15
Dispersion engineering of Schott-SF6 photonic crystal fibres for nonlinear applications in the infrared, Nicolas Joly[2,1], Xin Jiang[2], Riccardo Pennetta[2], Jonas Hammer[1,2], Fehim Babic[2], Philip S. Russell[2,1]; [1]*Universität Erlangen-Nürnberg, Germany;* [2]*Max-Planck Inst. for the Science of Light, Germany.* An empirical model for estimating the dispersion of solid-core Schott-SF6 photonic crystal fibre is presented. Finite element calculations and experimentally measured power-dependent spectra confirm the accuracy of the model.

FTh3B.4 • 15:30
Beam Self-Cleaning in Multimode Optical Fibers and Hydrodynamic 2D Turbulence, D. S. Kharenko[1,2], Oleg Sidelnikov[1,3], Vlad A. Gonta[1], M. D. Gervaziev[1], Katarzyna Krupa[4], Sergei K. Turitsyn[5,1], M. P. Fedoruk[1,3], E. V. Podivilov[1,2], Sergey A. Babin[1,2], Stefan Wabnitz[6,1]; [1]*Novosibirsk State Univ., Russia;* [2]*Inst. of Automation and Electrometry, SB RAS, Russia;* [3]*Inst. of Computational Technologies, SB RAS, Russia;* [4]*Univ. of Bourgogne, France;* [5]*Aston Univ., UK;* [6]*Sapienza Università di Roma, Italy.* We experimentally demonstrate the conservation of the average mode number in the process of Kerr beam self-cleaning in a graded-index multimode optical fiber, in analogy with wave condensation in hydrodynamic 2D turbulence.

FTh3C • Emission & Detection of Thermal Radiation—Continued

FTh3C.4 • 15:00
Nanoradiator-Mediated Deterministic Opto-Thermoelectric Manipulation, Yaoran Liu[1], Linhan Lin[1], Bharath Bangalore Rajeeva[1], Yuebing Zheng[1]; [1]*The Univ. of Texas at Austin, USA.* We explore the opto-thermoelectric trapping at plasmonic antennas that serve as optothermal nano-radiators to achieve the low-power and deterministic manipulation of nanoparticles.

FTh3C.5 • 15:15
Plasmonic photo-thermo-electric effect in graphene, Viktoryia Shautsova[2], Nicholas A. Güsken[1], Themistoklis Sidiropoulos[4], Xiaofei Xiao[1], Nicola Black[1], Adam M. Gilbertson[1], Vincenzo Giannini[1], Stefan Maier[1,3], Lesley Cohen[1], Rupert Oulton[1]; [1]*Physics, Imperial College London, UK;* [2]*Materials Dept., Oxford Univ., UK;* [3]*Physics, LMU Munich, Germany;* [4]*ICFO, Spain.* We present a novel photo-thermo-electric effect in graphene photo-detectors established by hot electrons concentration gradients at plasmonic contacts. Our description is crucial for an in depth understanding of graphene-based photodetection devices.

FTh3C.6 • 15:30
Field-Resolved Detection of the Temporal Response of a Mid-Infrared Plasmonic Antenna, Marco P. Fischer[2], Kevin F. Gallacher[3], Jacopo Frigerio[4], Giovanni Pellegrini[4], Giovanni Isella[4], Alfred Leitenstorfer[2], Douglas J. Paul[3], Paolo Biagioni[4], Daniele Brida[2,1]; [1]*Univ. of Luxembourg, Luxembourg;* [2]*Univ. of Konstanz, Germany;* [3]*Univ. of Glasgow, UK;* [4]*Politecnico di Milano, Italy.* We performed electro-optic sampling of the pulses re-emitted by a heavily-doped germanium antenna resonant in the mid-infrared. This field-resolved measurement allows observing the time domain response of a single plasmonic structure in amplitude and phase.

FTh3D • Quantum Photonics: Generation & Manipulation—Continued

FTh3D.2 • 15:00
On-chip nano-electro-mechanical switching of deterministic single photons, Xiaoyan Zhou[1], Camille Papon[1], Henri Thyrrestrup[1], Zhe Liu[1], Søren Stobbe[2,3], Rüdiger Schott[4], Andreas Wieck[4], Arne Ludwig[4], Peter Lodahl[1], Leonardo Midolo[1]; [1]*Center for Hybrid Quantum Networks, Niels Bohr Inst., Denmark;* [2]*Niels Bohr Inst., Denmark;* [3]*Dept. of Photonics Engineering, DTU Fotonik, Technical Univ. of Denmark, Denmark;* [4]*Ruhr-Universität Bochum, Germany.* We demonstrate a nano-electro-mechanical single-photon router integrated with semiconductor quantum emitters, showing an extinction ratio of >20 dB and operation speed of MHz with insertion loss of 0.67 dB and footprint <30 μm^2.

FTh3D.3 • 15:15
Integrated Quantum Photonics using Site-Controlled Quantum Dots and Tailored-Potential Photonic Crystals, Antoine M. Delgoffe[1], Alessio Miranda[1], Alexey Lyasota[1], Alok Rudra[1], Benjamin Dwir[1], Yi Yu[1,2], Eli Kapon[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*Technical Univ. of Denmark, Denmark.* We demonstrate several integrated photonics structures incorporating site-controlled quantum dots and photonic crystal cavities with tailored mode structures. Optimal designs for single photon extraction, routing and switching are presented and discussed.

FTh3D.4 • 15:30
Dual-Pump Design Enables Novel Photon-Pair Characterization and Engineering, Yujie Zhang[1], Ryan Spiniolas[1], Kai B. Shinbrough[1], Bin Fang[1], Offir Cohen[1], Virginia O. Lorenz[1]; [1]*Univ of Illinois at Urbana-Champaign, USA.* We experimentally demonstrate a dual-pump spontaneous four-wave mixing photon-pair source for which we quantify the noise to determine the generation probability and collection efficiency directly, and that generates photons in pure quantum states.

STh3E • Ultrafast Parametric Sources I—Continued

STh3E.3 • 15:00
A high power (11 W), tunable (1.45 – 1.65 µm) OPCPA for THz generation in organic crystals, Ivanka Grguras[1], Torsten Golz[1], Michael Schulz[1], Jan Heye Buß[1], Robert Riedel[1], Mark J. Prandolini[1]; [1]*Class 5 Photonics GmbH, Germany.* For THz generation using organic crystals, a high power, tunable (1.45 – 1.65 µm) OPCPA with pulse duration of < 36 fs at 350 kHz was developed. To enhance the flexibility of this system, a second synchronized probe channel is available, delivering compressed pulses at 850 nm with <15 fs.

STh3E.4 • 15:15
Optical parametric amplification of short-wave infrared monocycle pulses in BBO crystals pumped by red femtosecond pulses, Y. C. Lin[1], Yasuo Nabekawa[1], Katsumi Midorikawa[1]; [1]*RIKEN, Japan.* We generate infrared pulses with pulse duration of 5.3 fs (0.94 optical cycle) at the center wavelength of 1.7 µm via optical parametric amplification in BBO crystals, pumped by 708-nm femtosecond pulses.

STh3E.5 • 15:30
Compact 1-MHz, 1-µJ, Few-cycle, Passively CEP-stable 2-µm Source, Yizhou Liu[1,2], Peter Krogen[3], Kyung-Han Hong[4], Qian Cao[1,2], Philip Keathley[4], Franz Kärtner[2,1]; [1]*Hamburg Univ., Germany;* [2]*DESY, Germany;* [3]*Universität in Santa Barbara, USA;* [4]*MIT, USA.* We demonstrate a passively CEP-stable, 1-MHz, 2-µm dispersion managed optical parametric amplifier (OPA) with a chirped-pulse DFG front-end, pumped by an all fiber 1-µm source generating compressed µJ-level output pulses with 94.5 fs pulse duration.

STh3F • Nonlinear THz Phenomena—Continued

STh3F.2 • 15:00
Parallel-Plate THz Waveguides for Relativistic Electron Bunch Compression, Mohamed Othman[1], Matthias C. Hoffmann[1], Renkai Li[1], Emilio Nanni[1], Xijie Wang[1]; [1]*SLAC National Accelerator Lab, USA.* We present results from testing a new dispersion-free THz parallel-plate-based tapered structure optimized for focusing single-cycle THz pulses, producing high fields and with the potential for electron bunch compression to a few femtoseconds.

STh3F.3 • 15:15
Solid-state Biased Coherent Detection of Ultrabroadband Infrared Pulses Using Single Crystal of Diamond, Eiichi Matsubara[1,2], Masaya Nagai[2], Masaaki Ashida[2]; [1]*Osaka Dental Univ., Japan;* [2]*Engineering Science, Osaka Univ., Japan.* Using a high-voltage applied single crystal of diamond as a medium, we demonstrated the coherent detection of ultrabroadband infrared pulses generated from two-color pumped air plasma in a spectral range of 1−150 THz.

STh3F.4 • 15:30
Hidden Phase-Matched Narrowband THz Generation via Optical Rectification in Lithium Niobate, Dogeun Jang[1], Yung Jun Yoo[1], Ki-Yong Kim[1]; [1]*Univ. of Maryland at College Park, USA.* We observe efficient narrowband terahertz emission at 15 THz from lithium niobate crystals when irradiated by femtosecond Ti:sapphire laser pulses. This emission arises from phase-matched optical rectification in between resonance frequencies.

STh3G • Precision Timing & Optical Time Transfer—Continued

STh3G.4 • 14:45
Long-haul Transfer of Optical Frequencies in Free Space, Hyun Jay Kang[1], Jaewon Yang[1], Young-Jin Kim[2,1], Seung-Woo Kim[1]; [1]*South Korea Advanced Inst of Science & Tech, South Korea (the Republic of);* [2]*Nanyang Technology Univ., Singapore.* We report experimental results of concurrent transfer of multiple optical frequencies, coherently generated from an optical frequency comb, over an 18 km free-space link with real-time compensation of atmospheric phase noise.

STh3G.5 • 15:00
Laser Time Transfer Based on Micius Satellite, Hui Dai[1,2], Qi Shen[1,2], Shuang-Lin Li[1,2]; [1]*Shanghai Branch, National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Chinese Academy of Sciences (CAS) Center for Excellence and Synergetic Innovation Center in Quantum Information and Quantum Physics, Univ. of Science and Technology of China, China.* Based on Micius satellite, we demonstrate two satellite-to-ground laser time transfer experiments with high repetition rate and high precision. It shows the feasibility to combine time transfer network with quantum communication network.

STh3G.6 • 15:15
Attosecond Relative Timing Jitter between Optical Pulses and Rising Edges of Photocurrent Pulses, Minji Hyun[1], Yongjin Na[1], Hayun Chung[2], Jungwon Kim[1]; [1]*South Korea Advanced Inst of Science & Tech, South Korea (the Republic of);* [2]*South Korea Univ., South Korea (the Republic of).* We characterize relative timing jitter between optical pulses and photocurrent pulses with 300-attosecond resolution. We found that excess timing jitter at the rising edge can show ultra-low ~400-attosecond-level jitter for both p-i-n and MUTC photodiodes.

STh3H • Modulation & Switching—Continued

STh3H.4 • 15:00
Sub-V Opto-Electro-Mechanical Switch, Christian Haffner[1], Andreas Joerg[1], Felix M. Mayor[1], Michael Doderer[1], Daniel Chelladurai[1], Yuriy Fedoryshyn[1], Maurizio Burla[1], Cosmin Roman[1], Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland.* We demonstrate plasmonic-electro-mechanical-switches that feature a plasmonic resonator (Q>1000). This enables low on/off voltages (875mV) and low insertion losses (~1dB). The performance proofs that plasmonics is competitive with photonics not only at highest speed.

STh3H.5 • 15:15
Surface-Acoustic-Wave-Photonic Devices in Standard Silicon-on-Insulator, Dvir Munk[1], Moshe Katzman[1], Mirit Hen[1], Maayan Priel[1], Avi Zadok[1]; [1]*Bar-Ilan Univ., Israel.* Planar acousto-optic devices are implemented in standard silicon on insulator. Pump light is absorbed in metallic gratings. Stimulated surface waves modulate an optical probe in a ring resonator. Narrowband microwave photonic filtering is demonstrated.

STh3H.6 • 15:30
Resonant, High-frequency Acousto-Optic Modulators (AOM) Fabricated in a MEMS Foundry Platform, Krishna C. Coimbatore Balram[1], Stefano Valle[1]; [1]*QET Labs & Electrical and Electronic Engineering, Univ. of Bristol, UK.* We report the design and characterization of high frequency, resonant acousto-optic modulators in a MEMS foundry process. The doubly resonant cavity design allows us to measure acousto-optic modulation at frequencies upto 4 GHz with high modulation efficiency (V_π~350mV, f_{res}~2GHz).

Meeting Room 211 A/B

CLEO: Applications & Technology

ATh3I • A&T Topical Review on Silicon Photonics I—Continued

ATh3I.3 • 14:45
Silicon Photonics External Cavity Laser with Misalignment Tolerant Multi-mode RSOA to PIC Interface, Ibrahim Ghannam[1], Manuel Ackermann[1], Sebastian Romero-García[1], Florian Merget[1], Jeremy Witzens[1]; *[1]Inst. of Integrated Photonics, RWTH Aachen Univ., Germany.* We present an external cavity laser with a silicon photonics PIC coupled to an RSOA with a multimode grating coupler. Also acting as a 3-dB splitter inside a Sagnac loop, it relaxes alignment tolerances.

ATh3I.4 • 15:00
Vertically Coupled a-Si:H Multimode Interference Waveguides for Multi-layer Silicon Photonics Platform, Swe Z. Oo[1], Antulio Tarazona[1], Rafidah Petra[1,2], Ali Khokhar[1], Graham T. Reed[1], Anna C. Peacock[1], Harold M. Chong[1]; *[1]Univ. of Southampton, UK; [2]Universiti Teknologi Brunei, Brunei Darussalam.* We successfully demonstrated low temperature fabrication process of vertical MMI a:Si-H waveguides for multi-layer photonic integrated circuit. Measured MMI loss of 1.97dB/MMI and vertical light coupling of TE polarization at 1550nm wavelength have been achieved.

ATh3I.5 • 15:15 Invited
Silicon Photonics, Graham T. Reed[1]; *[1]Univ. of Southampton, UK.* In this paper we will discuss the use of ion implantation of Germanium into Silicon to introduce new functionality to Silicon Photonic circuits, from wafer scale testing, to device trimming and programmable photonic circuits

Meeting Room 211 C/D

CLEO: Science & Innovations

STh3J • Emerging Nonlinear Platforms—Continued

STh3J.4 • 14:45
Competing Faraday and modulational instabilities in dispersion-managed high-Q microcavities, Wenting Wang[1], Jinghui Yang[1], Abhinav Vinod[1], Hao Liu[1], Mingbin Yu[2], Dim Lee Kwong[2], Chee Wei Wong[1]; *[1]Univ. of California Los Angeles, USA; [2]Inst. of Microelectronics, Singapore.* We observed the competition between Faraday parametric instability and modulational instability in a dispersion-managed microcavity by changing the effective pump-resonance detuning. The Faraday ripple is triggered by the periodical oscillating group-velocity dispersion along the microcavity.

STh3J.5 • 15:00 Invited
Nonlinear Light Propagation in Crystals with Spatially Randomized Domains, Crina Cojocaru[1], Jose Trull[1], Wieslaw Krolikowski[2]; *[1]Dept. of Physics, Universitat Politecnica de Catalunya, Spain; [2]Texas A&M Univ. at Qatar, Qatar.* A study of the broad band spatial distributed second harmonic generation in a nonlinear crystal having a random size and distribution of nonlinear domains: applications to ultrashort pulse characterization and domain statistic characterization.

STh3J.6 • 15:30
Broadband randomly phase matched OPO using a thin 0.5-mm ZnSe ceramic and a dispersion-free cavity, Qitian Ru[1], Taiki Kawamori[1], Sergey Vasilyev[2], Sergey Mirov[2,3], Konstantin L. Vodopyanov[1]; *[1]CREOL, College of Optica and Photonics, Univ. of Central Florida, USA; [2]IPG Photonics - Mid-infrared Lasers, USA; [3]Dept. of Physics, Univ. of Alabama at Birmingham, USA.* We used a 0.5-mm randomly-phase-matched ZnSe polycrystal pumped by femtosecond 2.35-µm pulses and achieved a 3.2–9-µm-wide spectrum with 53-mW output power in a dispersion-free OPO cavity consisting of gold-coated mirrors and a pump injector.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATh3K • Trace Species Sensing—Continued

ATh3K.4 • 15:00
Dual-comb spectroscopy for the emission spectrum analysis, Liao Chen[1], Xi Zhou[1], Xin Dong[1], Yuhua Duan[1], Chi Zhang[1], Xinliang Zhang[1]; *[1]Wuhan National Lab for Optoelectronics, China.* A time-lens based dual-comb spectroscopy for the emission spectrum analysis is demonstrated. As a proof-of-concept, it achieves around 2-pm resolution and 7-nm bandwidth under 4-kHz frame rate, acts as a complementary for absorptive dual-comb spectroscopy.

ATh3K.5 • 15:15
Photoacoustic Pulse Width Measurement using Speckle Contrast Analysis, Matan Benyamin[1,2], Hadar Genish[2], Ran Califa[2], Nisan Ozana[1,2], Ariel Schwarz[2], Zeev Zalevsky[1,2]; *[1]Faculty of Engineering and the Nanotechnology center, Bar Ilan Univ., Israel; [2]ContinUse Biometrics, Israel.* A previously demonstrated non-expensive setup for remote photoacoustic signal detection, is extended to overcome its bandwidth limitations and obtain time-domain signal properties.

ATh3K.6 • 15:30
Methane excitation behavior as a comparison of InP, GaSb, IC and QC lasers excitation source by sensor applications, Tobias Milde[1,2], Morten Hoppe[1], Herve Tatenguem[1], Christian Assmann[1], Martin Honsberg[3], Wolfgang Schade[2], Joachim R. Sacher[1]; *[1]Sacher Lasertechnik GmbH, Germany; [2]Technische Universität Clausthal, Germany; [3]Sensor Photonics GmbH, Germany.* The MIR wavelength regime promises better gas detection possibilities than the NIR or the visible region because of the higher absorbencies simulated by HITRAN. These possibilities are tested with different lasers on TDLAS and QEPAS.

Meeting Room 212 C/D

CLEO: Science & Innovations

STh3L • Multi-Mode Fiber Phenomena I—Continued

STh3L.4 • 15:00
Multi-orthogonal High-order Modes Converter, Linghao Meng[1], Jianfeng Lu[1], Longkun Zhang[1], Fan Shi[1], Xianglong Zeng[1]; *[1]Shanghai Univ., China.* We demonstrate a fiber laser based on a cascaded AIFGs with flexible switching output of multiple modes (LP01, $LP_{11}^{a/b}$, $LP_{2}^{1a/b}$, LP_{02}). This has potential application in mode division multiplexing, multimode fiber laser.

STh3L.5 • 15:15
Robust compressive imaging through single multimode fiber with millimeter depth of field against bending, Di Guan[1], Li Gao[1], Junhui Li[1], Mingying Lan[1], Yangyang Xiang[1], Guohua Wu[1], Song Yu[1]; *[1]Beijing Univ. Posts & Telecommunications, China.* Single pixel imaging experiment through single multimode fiber demonstrates capability of multi-millimeter depth of field, almost three orders larger than previous work, also robustness against fiber configuration change caused by bending.

STh3L.6 • 15:30
Intracavity cylindrical vector beam generation from an all-PM Er-doped mode-locked fiber laser, Yuwei Zhao[1], Jintao Fan[1], Ruoyu Liao[1], Youjian Song[1], Ming-lie Hu[1]; *[1]Tianjin Univ., China.* We demonstrate a practical method to generate on-demand 1^{st} order and higher order cylindrical vector beams in the 1550 nm band directly from an all-PM mode-locked Er-fiber laser.

CLEO: QELS-Fundamental Science

FTh3M • Metasurfaces—Continued

FTh3M.4 • 14:45
Metasurface Optics for Ultra-Compact Augmented Reality (AR) Visors, Elyas Bayati[1], Shane Colburn[1], Arka Majumdar[1]; [1]*Univ. of Washington , USA.* We propose to design the next generation of metasurface near-eye visors which will circumvent real-world distortions and provide a large field of view, as needed for an immersive AR experience.

FTh3M.5 • 15:00
Artifact-free Phase-Amplitude Metasurface Hologrpahy at up to Three Wavelengths, Adam C. Overvig[1], Sajan Shrestha[1], Stephanie Malek[1], Nanfang Yu[1]; [1]*Columbia Univ., USA.* We report numerical and experimental demonstrations of phase-amplitude metasurface holograms capable of producing 2D holographic images free of "ringing artifacts". By using a metasurface doublet, this can be extended to three colors simultaneously.

FTh3M.6 • 15:15
Gap-surface Plasmon Metasurfaces for Focused Structured-beams Generation, Fei Ding[1], Sergey I. Bozhevolnyi[1]; [1]*Univ. of Southern Denmark, Denmark.* Capitalizing on gap-surface plasmon metasurfaces (GSPMs), we experimentally generate focused structured-beams in the near-infrared range (750–950 nm) with broadband and highly-efficient performance, including the polarized-converted focused vortex beam (PCFVB) and focused vector-beam (FVB).

FTh3M.7 • 15:30
Semiconductors Meta-Optics: Fabrication and Applications, Gauthier Briere[1], Peinan Ni[1], Sebastien Heron[1], Sebastien Chenot[1], Stephane Vezian[1], Virginie Brandli[1], Benjamin Damilano[1], Jean Yves Duboz[1], Masanobu Iwanaga[2], Patrice Genevet[1]; [1]*CNRS, France;* [2]*NIMS, Japan.* In this work we present metasurfaces based on Gallium Nitride material. We propose a fabrication method able to preserve the active optical properties of semiconductors, thus paving the way for the realization of tunable metadevices. ©2019 Briere Gauthier, Patrice Genevet.

CLEO: Science & Innovations

STh3N • Hybrid Integration with Si Photonics—Continued

STh3N.4 • 14:45
Hybrid Silicon-Conductive Oxide Microring Resonators with 261pm/V Tunability, Behzad Ashrafi Nia[1], Erwen Li[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* We designed and demonstrated a silicon microring filter with indium-tin oxide gate as the electric-tuning electrode. It achieved ultra-large resonance wavelength tunability of 261pm/V, which is obtained through the high-K HfO_2 insulated capacitor.

STh3N.5 • 15:00 Invited
III-V Lasers Emitting at 1.3 to 1.5 mm grown on (001) silicon by MOCVD, Kei May Lau[1]; [1]*Hong Kong Univ of Science and Technology, USA.* We report the growth of quantum-well and quantum-dot lasers on compliant InP/Si substrates by MOCVD. Laser characteristics at 1.3 to 1.5 mm from whispering-gallery-mode (WGM) micro-lasers, nano-ridge lasers and conventional Fabry-Perot lasers will be described.

STh3N.6 • 15:30
Low-Loss TeO_2 Waveguides Integrated on a Si_3N_4 Platform for Active and Nonlinear Optical Devices, Henry Frankis[1], Khadijeh Kiani[1], Dawson Bonneville[1], Chenglin Zhang[1], Samuel Norris[2], Richard Mateman[3], Arne Leinse[3], Nabil D. Bassim[2], Andrew P. Knights[1], Jonathan D. B. Bradley[1]; [1]*Engineering Physics, Canada;* [2]*Materials Science and Engineering, McMaster Univ., Canada;* [3]*LioniX International, Netherlands.* We report on TeO_2-coated Si_3N_4 waveguides with losses down to 0.6 dB/cm at 2 µm. These results are a promising step towards realizing scalable, compact and high-performance tellurite glass devices on a silicon nitride platform.

STh3O • 2D Materials—Continued

STh3O.4 • 14:45
Energy Transport at Hybrid Organic-MoS_2 Interface, Che-Hsuan Cheng[1], Zidong Li[1], Parag Deotare[1]; [1]*Univ. of Michigan, USA.* We report energy transport of charge transfer (CT) excitons at the hybrid interface of low dimensional materials. We find that the transport of hybrid CT excitons is eight times faster than MoS_2 A-excitons.

STh3O.5 • 15:00
Pseudo-van der Waals Epitaxy of MoS_2 on Patterned and Planar GaN Substrates, Xiuling Li[1], Hao-Chung Kuo[2], Weidong Zhou[3], Che-Yu Liu[2], Wonsik Choi[1], Hsien-Chih Huang[1]; [1]*Univ. of Illinois, USA;* [2]*National Chiao Tung Univ., Taiwan;* [3]*Univ. of Texas at Arlington, USA.* n-MoS2/p-GaN diodes monolithically formed by pseudo-van der Waals epitaxy show well-defined rectifying behavior. Growth on patterned GaN substrates yields monolayer and few-layer MoS_2 formation on the planar surface and the pyramids, respectively.

STh3O.6 • 15:15
Cryogenic Micro-PL of Monolayer 1T/2H MoS2 Superlattice, Zhangji Zhao[1], Ibrahim Sarpkaya[2], Xuejun Xie[3], Kaustav Banerjeeand[3], Han Htoon[2], Chee Wei Wong[1]; [1]*Univ. of California Los Angeles, USA;* [2]*Center for Integrated Nanotechnologies, Los Alamos National Lab, USA;* [3]*Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA.* We investigate E-beam irradiated 1T-Phase quantum dots on 2H-MoS_2 by photoluminescence (PL) spectroscopy and mapping. Red-shifted PL spectra from quantum dots under different dose levels are greatly enhanced under 10K than 300K.

STh3O.7 • 15:30 Invited
Terahertz and Nonlinear Optics in Graphene, Thomas E. Murphy[1]; [1]*Univ. of Maryland at College Park, USA.* Graphene exhibits unusual optical and thermal properties that allow electrons to be efficiently heated by THz illumination. We discuss the nature, origin, and measurement of the nonlinear response of graphene in the THz regime.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTh3A • Gateways to Quantum Information Processing—Continued

FTh3B • Tailorable Phenomena in Optical Fibers—Continued

FTh3B.5 • 15:45
Dynamics of photon fluid flows driven by optical pistons, Abdelkrim Bendahmane[1], Gang XU[1], Matteo Conforti[1], Alexandre Kudlinski[1], Arnaud Mussot[1], Stefano Trillo[2]; [1]*CNRS / Lille Univ., France;* [2]*Univ. of Ferrara, Italy.* We investigate the optical analogous of the piston shock problem in gas dynamics. Using fast temporal measurements, we recorded dispersive shock waves formed by the propagation of a bi-chromatic photon fluid along an optical fiber.

FTh3C • Emission & Detection of Thermal Radiation—Continued

FTh3C.7 • 15:45
Tunable Hyperbolic Plasmons in Self-Assembled Carbon Nanotube Metamaterials, John A. Roberts[1], Shang-Jie Yu[2], Abram Falk[3], Po-Hsun Ho[3], Stefan Schoeche[4], Jonathan A. Fan[2]; [1]*Dept. of Applied Physics, Stanford Univ., USA;* [2]*Dept. of Electrical Engineering, Stanford Univ., USA;* [3]*IBM T.J. Watson Research Center, USA;* [4]*J.A. Woollam Co., Inc., USA.* We show that self-assembled aligned carbon nanotubes are a tunable hyperbolic metamaterial using spectroscopic ellipsometry. We map the hyperbolic dispersion of plasmonic modes in aligned carbon nanotube films using transmission measurements of nanoribbon resonators.

FTh3D • Quantum Photonics: Generation & Manipulation—Continued

FTh3D.5 • 15:45
High visibility Hong-Ou-Mandel interference between independent single photon sources obtained from multi-stage nonlinear interferometers, Jiamin Li[1], Jie Su[1], Liang Cui[1], Xiaoying Li[1], Z. Y. Ou[1,2]; [1]*Tianjin Univ., China;* [2]*Indiana Univ.–Purdue Univ. Indianapolis, USA.* Using spontaneous four-wave mixing in a 3-stage nonlinear interferometer for temporal mode shaping, we efficiently generate heralded single photons in single-mode, evidenced by a visibility of 90% in Hong–Ou–Mandel interference between independent sources.

16:00–16:30 Coffee Break, *Concourse Level*

STh3E • Ultrafast Parametric Sources I—Continued

STh3F • Nonlinear THz Phenomena—Continued

STh3F.5 • 15:45
New horizons for high power broadband THz sources driven by ultrafast Yb-based thin disk laser oscillators, Jakub Drs[1], Norbert Modsching[1], Christian Kränkel[2], Valentin J. Wittwer[1], Olga Razskazovskaya[1], Thomas Südmeyer[1]; [1]*Université de Neuchâtel, Switzerland;* [2]*Center for Laser Materials, Leibniz-Institut für Kristallzüchtung, Germany.* We confirm the high suitability of ultrafast thin-disk lasers for THz generation, achieving up to 0.33-mW broadband THz radiation in GaP. Moreover, we show 7-THz gapless spectrum by optimization of crystal length and pulse duration.

STh3G • Precision Timing & Optical Time Transfer—Continued

STh3G.7 • 15:45
Rapid and Precise Displacement Measurement Using Time-of-Flight Detection of Femtosecond Optical Pulses, Yongjin Na[1], Minji Hyun[1], Chan-Gi Jeon[1], Jungwon Kim[1]; [1]*South Korea Advanced Inst of Science & Tech, South Korea (the Republic of).* We demonstrate high-speed and high-resolution displacement measurement method by utilizing electro-optic sampling between electrical pulses from photodetection and femtosecond optical pulses. A 5.8-nm (1.9-nm) resolution is achieved in only 50 µs (14 ms) update time.

STh3H • Modulation & Switching—Continued

STh3H.7 • 15:45
A Wideband On-Chip Radiator Driven by a Traveling-Wave Photodetector, Craig Ives[1], Behrooz Abiri[2], Ali Hajimiri[1]; [1]*California Inst. of Technology, USA;* [2]*Auspion Inc., USA.* An integrated broadband Vivaldi antenna driven by an on-chip traveling-wave photodetector is reported. The silicon photonic chip radiates between 21 and 67 GHz with -65 dBm coupled power at 44 GHz.

16:00–16:30 Coffee Break, *Concourse Level*

Meeting Room 211 A/B

CLEO: Applications & Technology

ATh3I.6 • 15:45
Electro-Optics with Gigahertz Phonons in Silicon Photonics, Raphaël Van Laer[1], Rishi Patel[1], Jeremy D. Witmer[1], Timothy McKenna[1], Amir Safavi-Naeini[1]; [1]*Stanford Univ., USA.* We demonstrate effective piezoelectricity in silicon nanophotonic structures by breaking silicon's inversion symmetry with an electrical bias field. The devices show promise as low-energy microwave-to-optical interfaces for use in classical and quantum communications.

Meeting Room 211 C/D

CLEO: Science & Innovations

STh3J.7 • 15:45
Logic Gates based on Interaction of Counterpropagating Light in Microresonators, Niall Moroney[1,2], Leonardo Del Bino[1,3], Michael T. M. Woodley[1,3], Jonathan M. Silver[1,4], George Ghalanos[1,2], Andreas Svela[1,2], Shuangyou Zhang[1], Pascal Del'Haye[1]; [1]*National Physical Lab, UK;* [2]*Physics, Imperial College London, UK;* [3]*Heriot-Watt Univ., UK;* [4]*City, Univ. of London, UK.* We demonstrate a novel optical logic gate that is mediated by the Kerr effect of counter-propagating beams in a whispering gallery mode microresonator. The universal gate A &¬ B is presented.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATh3K.7 • 15:45
High Speed Measurements and Enhancement of QEPAS Sensitivity: Quartz Resonance Frequency Tracking, Herve Tatenguem Fankem[1], Andreas Sacher[1], Morten Hoppe[1], Tobias Milde[1], Joachim R. Sacher[1]; [1]*Sacher Lasertechnik GmbH, Germany.* This study reports on the development of a platform based-on a Field-Programmable Gate Arrays (FPGAs) and suitable for high speed measurements and enhancement of QEPAS sensitivity.

Meeting Room 212 C/D

CLEO: Science & Innovations

16:00–16:30 Coffee Break, *Concourse Level*

Marriott Salon I & II

CLEO: QELS-Fundamental Science

FTh3M.8 • 15:45
Near-IR Wide Field-of-View Huygens Metalens for Outdoor Imaging Applications, Jacob Engelberg[1], Chen Zhou[2], Noa Mazurski[1], Jonathan Bar-David[1], Uriel Levy[1], Anders Kristensen[2]; [1]*Applied Physics, Hebrew Univ. Jerusalem Israel, Israel;* [2]*Micro- and Nanotechnology, Technical Univ. of Denmark, Denmark.* We present a Huygens nano-antenna based metalens, designed for outdoor photographic applications in the near-infrared. We show that good imaging quality can be obtained over a moderate ±15 degree field-of-view (FOV).

Marriott Salon III

Marriott Salon IV

CLEO: Science & Innovations

STh3N.7 • 15:45
Low Loss, Compact Waveguides in GaAs/Oxidized AlGaAs Layers Directly Grown on Silicon, Prashanth Bhasker[1], Chen Shang[1], John Bowers[1], Nadir Dagli[1]; [1]*Univ. of California, Santa Barbara, USA.* Waveguides in high index contrast GaAs/Oxidized AlGaAs layers directly grown on silicon are presented. These are very similar to waveguides in Si photonics and can be the basis of very high performance photonic integration platform.

16:00–16:30 Coffee Break, *Concourse Level*

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

16:30–18:30
FTh4A • New Protocols in Quantum Communications
Presider: Michael Brodsky; US Army Research Laboratory, USA

FTh4A.1 • 16:30
Quantum Multiplexing, William Munro[1,2], Nicolo Lo Piparo[2], Kae Nemoto[2]; [1]*NTT Basic Research Labs, Japan;* [2]*National Inst. for Informatics, Japan.* We introduce the concept of quantum-multiplexing for quantum communication systems and repeater networks, which allows us minimize the number of photons needed in entanglement distribution while enhancing the quality of the entangled pairs generated.

FTh4A.2 • 17:00
Quantum Low Probability of Intercept, Jeffrey H. Shapiro[1], Don Boroson[2], P. Ben Dixon[2], Matthew Grein[2], Scott Hamilton[2]; [1]*MIT, USA;* [2]*MIT Lincoln Lab, USA.* Quantum low probability of intercept transmits ciphertext in a way that prevents an eavesdropper possessing the decryption key from recovering the plaintext. It is capable of Gbps communication rates on optical fiber over metropolitan-area distances.

16:30–18:30
FTh4B • Non-Diffractive & Vortex Beams
Presider: To Be Announced

FTh4B.1 • 16:30
Demonstration of turbulence-resistant propagation of anti-diffracting optical beams beyond kilometer distances, Ze Zhang[1], Xinli Liang[1], Mihalis Goutsoulas[2], Nikos Efremidis[2], Zhigang Chen[3,4]; [1]*Aerospace Information Research Inst., Chinese Academy of Sciences, China;* [2]*Dept. of Applied Mathematics, Univ. of Crete, Greece;* [3]*The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [4]*Dept. of Physics and Astronomy, San Francisco State Univ., USA.* We demonstrate robust propagation of anti-diffracting optical beams through atmosphere turbulence beyond kilometer distances. Such Airy-Bessel-like light beams surpass conventional Bessel beams and can, in principle, exhibit "self-focusing" in free space without any optical nonlinearity.

FTh4B.2 • 16:45
Coherent Propulsion with Negative-mass Fields in a Photonic Setting, Yumiao Pei[1], Yi Hu[1], Ping Zhang[1], Chunmei Zhang[1], Cibo Lou[2], Christian E. Rüter[3], Detlef Kip[3], Demetrios N. Christodoulides[4], Zhigang Chen[1,5], Jingjun Xu[1]; [1]*Nankai Univ., China;* [2]*Ningbo Univ., China;* [3]*Helmut Schmidt Univ., Germany;* [4]*Univ. of Central Florida, USA;* [5]*San Francisco State Univ., USA.* We demonstrate an optical self-accelerating state driven by nonlinear coherent interaction of its constituting components with opposite "mass-sign". The coherent propulsion, highly immune to initial phase conditions, is surprisingly enhanced comparing to its incoherent counterpart.

FTh4B.3 • 17:00
Engineering the Wavelength and Topological Charge of Non-Diffracting Beams Along Their Axis of Propagation, Ahmed Dorrah[1], Michel Zamboni-Rached[2], Mo Mojahedi[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [2]*School of Electrical and Computer Engineering, Univ. of Campinas, Brazil.* We present non-diffracting structured light beams in which their wavelength and local orbital angular momentum can be changed independently and "at will" along the axis of propagation, thus opening new possibilities in laser processing, micromanipulation, and data communications.

16:30–18:30
FTh4C • Advanced Nanophotonic Platforms for Spectroscopy & Sensing
Presider: Ofer Kfir; University of Göttingen, Germany

FTh4C.1 • 16:30 Invited
Plasmonic Waveguiding Spectroscopy and Microscop, Hiroshi Ujii[1,2], Shuichi Toyouchi[2], Tomoko Inose[1], Yasuiko Fujita[2]; [1]*Hokkaido Univ., Japan;* [2]*Chemistry, KU Leuven, Belgium.* In this contribution, various applications of plasmonic waveguide will be introduce. Specifically, we will introduce remote excitation of surface enhanced Raman scattering inside a live cell or material surface.

FTh4C.2 • 17:00
Nanospectroscopic Imaging of Vibrational Excitons as a Molecular Ruler, Thomas P. Gray[1], Eric A. Muller[1], Omar Khatib[1,2], Hans Bechtel[2], Markus B. Raschke[1]; [1]*Physics, Univ. of Colorado Boulder, USA;* [2]*Advanced Light Source Division, Lawrence Berkeley National Lab, USA.* We demonstrate infrared vibrational nano-spectroscopy and -imaging using the evolution of vibrational marker resonances as a molecular ruler to map nanoscale crystallinity in molecular electronic materials.

16:30–18:30
FTh4D • Beyond Photon Pairs
Presider: Marty Stevens, NIST Boulder Colorado, USA

FTh4D.1 • 16:30
Repeater-enhanced distributed quantum sensing based on continuous-variable multipartite entanglement, Yi Xia[1], Quntao Zhuang[2], William Clark[3], Zheshen Zhang[1]; [1]*Univ. of Arizona, USA;* [2]*Univ. of California, Berkeley, USA;* [3]*General Dynamics Mission systems, USA.* We show that noiseless linear amplifiers can serve as quantum relays to overcome entanglement distribution loss for entangled quantum sensors to outperform sensors supplied with the optimum local quantum resources.

FTh4D.2 • 16:45
Plug-and-Play squeezing experiment on chip at telecom wavelength, François Mondain[2,1], Tommaso Lunghi[2,1], Alessandro Zavatta[3,4], Élie Gouzien[2,1], Florent Doutre[2,1], Marc De Micheli[2,1], Sébastien Tanzilli[2,1], Virginia D'Auria[2,1]; [1]*Institut de Phyisque de Nice (INPHYNI), France;* [2]*Université Côte d'Azur (UCA), France;* [3]*Istituto Nazionale Di Ottica (INO-CNR), Italy;* [4]*Lens and Dept. of Physics Universita Di Firenze, Italy.* We demonstrate a plug-and-play squeezing experiment entirely based on off-the-shelves guided-wave components and lithium-niobate integrated optics. We achieve -2 dB of squeezing thus validating our original approach as a resource for real-world continuous-variables implementations.

FTh4D.3 • 17:00 Invited
Lithium Niobate as a Platform for Continous Variable Quantum Optics, Mirko Lobino[1], Francesco Lenzini[1], Jiri Janousek[2], Oliver Thearle[2], Matteo Villa[1], Ben Haylock[1], Sachin Kasture[1], Liang Cui[3], Hoang-Phuong Phan[1], Dzung Viet Dao[1], Hidehiro Yonezawa[4], Ping Koy Lam[2], Elanor H. Huntington[2]; [1]*Griffith Univ., Australia;* [2]*Australian National Univ., Australia;* [3]*Tianjin Univ., China;* [4]*The Univ. of New South Wales, Australia.* I will report on the progress towards a fully integrated platform for continuous variable quantum optics in lithium niobate. Our device incorporates generation, manipulation, and detection of nonclassical state of light on a single chip.

Executive Ballroom 210E

CLEO: Science & Innovations

16:30–18:30
STh4E • Ultrafast Parametric Sources II
Presider: Jake Bromage; Univ. of Rochester, USA

STh4E.1 • 16:30
High-Power, Widely-Tunable Femtosecond Cylindrical Vector Beam Optical Parametric Oscillator, Jun Zhao[1], Jintao Fan[1], Na Xiao[1], Youjian Song[1], Ming-lie Hu[1]; [1]*Tianjin Univ., China.* We propose a cylindrical vector beam optical parametric oscillator, which is capable of delivering on demand vector beam tunable across 1405~1601 nm directly, with a maximum power of 614 mW at 1505 nm.

STh4E.2 • 16:45
Intracavity enhancement in a doubly resonant OPO, Christian M. Dietrich[1], Ihar Babushkin[1,2], José Andrade[1,3], Laura Rust[1], Uwe Morgner[1,3]; [1]*Inst. of Quantum Optics and PhoenixD, Germany;* [2]*Max Born Inst., Germany;* [3]*Hannover Centre for optical Technologies, Germany.* We show that strong cavity-induced enhancement of signal and idler power with respect to the pump can be achieved intracavity in a doubly resonant optical parametric oscillator pumped by an Yb:YAG thin-disk laser oscillator.

STh4E.3 • 17:00
5-Octave Laser Source Based on Cr:ZnS-GaSe Tandem, Sergey Vasilyev[1], Igor S. Moskalev[1], Viktor O. Smolski[1], Jeremy Peppers[1], Mike Mirov[1], Andrey V. Muraviev[3], Konstantin L. Vodopyanov[3], Sergey Mirov[1,4], Valentin P. Gapontsev[2]; [1]*IPG Photonics - Southeast Technology Center, USA;* [2]*IPG Photonics Corporation, USA;* [3]*CREOL, Univ. of Central Florida, USA;* [4]*Dept. of Physics, Univ. of Alabama at Birmingham, USA.* We report laser architecture that enables generation of coherent femtosecond continua that span from visible to long-wave IR (0.5–18 μm), and features: high power (4W), high repetition rate (80 MHz), and intrinsic nonlinear interferometry.

Executive Ballroom 210F

Joint

16:30–18:30
JTh4F • Interaction of Strong THZ Fields with Condensed Matter Systems
Presider: Dmitry Turchinovich, Universität Bielefeld, Germany

JTh4F.1 • 16:30
THz-Pump UED-Probe on a Topological Weyl Semimetal, Edbert Sie[1], Clara Nyby[1], Das Pemmaraju[2], Su Ji Park[2], Xiaozhe Shen[2], Jie Yang[2], Matthias C. Hoffmann[2], Benjamin Ofori-Okai[2], Renkai Li[2], Alexander Reid[2], Stephen Weathersby[2], Ehren Mannebach[1], Nathan Finney[3], Daniel Rhodes[3], Daniel Chenet[3], Abhinandan Antony[3], Luis Balicas[4], James Hone[3], Thomas Devereaux[1], Tony Heinz[1], Xijie Wang[2], Aaron Lindenberg[1,2]; [1]*Stanford Univ., USA;* [2]*SLAC National Accelerator Lab, USA;* [3]*Columbia Univ., USA;* [4]*National High Magnetic Field Lab, USA.* We used THz pulses to drive a topological transition in a Weyl semimetal WTe_2 via interlayer shear motion, as crystallographically measured using ultrafast electron diffraction (Sie et al, Nature (2018), in press).

JTh4F.2 • 17:00
Lightwave Driven Valleytronic Qubit Flip, Markus Borsch[1], Benjamin Girodias[1], Johannes T. Steiner[2], Stephan W. Koch[2], Christoph P. Schmid[3], Stefan Schlauderer[3], Fabian Langer[3], Rupert Huber[3], Mackillo Kira[1]; [1]*Univ. of Michigan, USA;* [2]*Univ. of Marburg, Germany;* [3]*Univ. of Regensburg, Germany.* We demonstrate a flip of the valley pseudo-spin in a tungsten-diselenide monolayer on a sub-5fs timescale using strong terahertz fields. The resulting sideband emission reveals Coulombic many-body effects.

Executive Ballroom 210G

CLEO: Science & Innovations

16:30–18:30
STh4G • Opto-mechanics
Presider: Shau-Yu Lan; Nanyang Technological University, Singapore

STh4G.1 • 16:30
High-Bandwidth Force Sensing with Optical Cavities, Benjamin Reschovsky[1], Akobuije Chijioke[1]; [1]*National Inst. of Standards and Technology, USA.* We present a method for measuring dynamic forces by tracking induced frequency shifts of optical cavity resonances with initial tests of a robust laser stabilization scheme featuring large dynamic-range (5 GHz) and high-bandwidth (>1 MHz).

STh4G.2 • 16:45
Optical Loss Uniformity Characterization Using Scanning Cavity Ringdown Measurements, Gar-Wing Truong[1], Tobias Zederbauer[2], Dominic Bachmann[2], Paula Heu[1], David Follman[1], Mark E. White[1], Garrett D. Cole[1]; [1]*Crystalline Mirror Solutions, USA;* [2]*Crystalline Mirror Solutions GmbH, Austria.* A cavity ringdown system for probing the spatial variation of optical loss in a high-reflectivity optical interference coating is described. Excellent agreement is observed between the spatial map and differential interference contrast microscopy images of a substrate-transferred crystalline mirror.

STh4G.3 • 17:00
Quasi-2D Optomechanical Crystal Cavity for Quantum Optomechanics, Hengjiang Ren[1], Gregory S. MacCabe[1], Jie Luo[1], Hannes Pfeifer[2], Andrew Keller[1], Oskar Painter[1]; [1]*Inst. for Quantum Information and Matter and Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA;* [2]*Max Planck Inst. for the Science of Light, Germany.* We present the design and characterization of a quasi-two-dimensional optomechanical crystal cavity. At refrigerated temperature, an intrinsic mechanical quality factor of 1.2 billion is observed and an effective quantum cooperativity greater than unity is realized under steady-state optical pumping.

Executive Ballroom 210H

16:30–18:30
STh4H • Optical Driven Photonics
Presider: Carl Liebig; AFRL, USA

STh4H.1 • 16:30 Invited
Picosecond Optical Switching in Silicon Photonics Using Phase-Changing Vanadium Dioxide, Richard F. Haglund[1], Kent A. Hallman[1], Kevin J. Miller[1], Sharon M. Weiss[1]; [1]*Vanderbilt Univ., USA.* Experiments in hybrid vanadium dioxide-silicon photonic structures, complemented by finite-difference, time-domain simulations, show how the ultrafast insulator-to-metal transition in VO_2can be leveraged in nanoscale photonic structures to open new routes to low-loss, high-speed all-optical modulators.

STh4H.2 • 17:00
All-optical synapses based on silicon microring resonators actuated by the phase change material $Ge_2Sb_2Te_5$, Zahng Hanyu[1], Linjie Zhou[1], Xu Jian[1], Liangjun Lu[1], Jianping Chen[1], B. M. A. Rahman[2]; [1]*Shanghai Jiao Tong Univ., China;* [2]*City, Univ. of London, UK.* We demonstrate silicon microring resonators integrated with $Ge_2Sb_2Te_5$ material that can be used as all-optical synapses for neuromorphic computing. Synaptic plasticity is investigated with different resonator coupling conditions.

Meeting Room 211 A/B

CLEO: Applications & Technology

16:30–18:30
ATh4I • A&T Topical Review on Silicon Photonics II
Presider: To Be Announced

ATh4I.1 • 16:30 Invited
Applications of Integrated Kerr Microcombs to Radio Frequency and Microwave Photonics, Xingyuan Xu,[1] Jiayang Wu,[1] Mengxi Tan,[1] Thach Nguyen[2], Sai T. Chu,[3] Brent E. Little,[4] Roberto Morandotti,[5] Arnan Mitchell,[2] and David J. Moss[1],; [1]*Centre for Micro-Photonics, Swinburne University of Technology, Hawthorn, VIC 3122 Australia,* [2]*School of Engineering, RMIT University, Melbourne, VIC 3000, Australia,* [3]*Department of Physics and Material Science, City University of Hong Kong, Hong Kong, China,* [4]*Xi'an Institute of Optics and Precision Mechanics Precision Mechanics of CAS, Xi'an, China,* [5]*INRS –Énergie, Matériaux et Télécommunications, Varennes, Québec, J3X 1S2, Canada.* We review our recent work in the use of integrated micro-resonator based optical frequency comb sources as the basis for transversal filtering functions for microwave and radio frequency photonic filtering and advanced functions. We demonstrate a range of novel functions including a Hilbert Transform, first, second and third order RF differentiation, true time delays, an RF channelizer and other functions.

ATh4I.2 • 17:00
Silicon photonics optical frequency synthesizer - SPOFS, Neetesh Singh[1], Ming Xin[1], Nanxi Li[1], Diedrik Vermeulen[1], Alfonso Ruocco[1], Emir Salih Magden[1], Katia Shtyrkova[1], Patrick Callahan[1], Erich Ippen[1], Franz Kartner[2], Michael R. Watts[1]; [1]*MIT, USA;* [2]*CFEL, DESY, Germany.* We demonstrate a silicon photonics optical frequency synthesizer (SPOFS). The frequency instability obtained in the telecom band is $1x10^{-12}$ at 1s level, comparable to a bench-top commercial optical frequency synthesizer system.

Meeting Room 211 C/D

CLEO: Science & Innovations

16:30–18:30
STh4J • Applications of Lasers & Microcombs
Presider: Yoshitomo Okawachi; Columbia Univ., USA

STh4J.1 • 16:30
Noise Filtering in Synchronously-driven Kerr Frequency Combs, Victor Brasch[1], Ewelina Obrzud[1,2], Steve Lecomte[1], Tobias Herr[1]; [1]*CSEM, Switzerland;* [2]*Dept. of Astronomy, Univ. of Geneva, Switzerland.* We demonstrate filtering of an electro-optic modulation frequency comb in a high-Q Fabry-Perot microresonator via different regimes. Using dissipative Kerr solitons the coherence of the electro-optic modulation comb is improved, allowing for more advanced applications.

STh4J.2 • 16:45
Photonic Integrated K-Band Microwave Oscillator Based on Silicon Nitride Soliton Microcomb, Junqiu Liu[1], Arslan Raja[1], Erwan Lucas[1], Jijun He[1], Guanhao Huang[1], Romain Bouchand[1], Rui Ning Wang[1], Maxim Karpov[1], Nils Engelsen[1], Hairun Guo[1], Tobias J. Kippenberg[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* Using photonic integrated silicon nitride microresonators of quality factor exceeding 15 million, we demonstrate 19-GHz-repetition-rate single soliton with 35 mW optical power, and characterize the phase noise of the repetition rate in the K-band microwave regime.

STh4J.3 • 17:00
Dual-comb imaging using soliton microcombs, Chengying Bao[1], Myoung-Gyun Suh[1], Kerry J. Vahala[1]; [1]*Caltech, USA.* We demonstrate rapid imaging using dual-microcomb interferometry. One of the soliton microcombs is spatially dispersed into two dimensions to record spatial information and the image is read out by multi-heterodyne with the second microcomb.

Meeting Room 212 A/B

CLEO: Applications & Technology

16:30–18:30
ATh4K • Sources & Techniques for Industrial Monitoring
Presider: Brian Simonds, National Institute of Standards and Technology, USA

ATh4K.1 • 16:30
A Breakthrough Industrial THz Application: Robust In-situ THz-based Paint Layer Monitoring, Deran Maas[1], Andreas Frank[1], Jacobus L. van Mechelen[1]; [1]*Corporate Research, ABB Switzerland, Switzerland.* We present a THz paint analyzer for measuring wet and dry paint multilayers insensitive to surface curvatures and vibrations. The layers can be measured simultaneously with an average error smaller than 1.1 µm.

ATh4K.2 • 16:45
Two-phase flow monitoring with an electrical-optical probe, Rosangela Winter[1], Eduardo Nunes do Santos[1], Rigoberto Eleazar Melgarejo Morales[1], Cicero Martelli[1], Marco José da Silva[1], Jean Carlos Cardozo da Silva[1]; [1]*Federal Univ. of Technology - Paraná, Brazil.* An electrical-optical probe was developed to monitor monophasic and biphasic flow in industrial environments. The probe measures the parameters of electrical conductance and mechanical strain, thereby introducing data redundancy and facilitating auto calibration.

ATh4K.3 • 17:00
Continuous Optical Measurement of Dynamic Colloidal Droplets, Jose Guzman-Sepulveda[1], Ruitao Wu[1], Aristide Dogariu[1]; [1]*Univ. of Central Florida, USA.* We demonstrate the use of spatiotemporal coherence-gated light scattering for measuring the dynamics of colloidal droplets during drying. The measurement is non-contact, non-invasive, and label-free, and permits monitoring the internal structure in optically-isolated, picolitter-sized volumes.

Meeting Room 212 C/D

CLEO: Science & Innovations

16:30–18:30
STh4L • Multi-Mode Fiber Phenomena II
Presider: Julien Fatome; Universite de Bourgogne, France

STh4L.1 • 16:30
Self-Cleaning on a Higher Order Mode in Ytterbium-Doped Multimode Fiber with Parabolic Profile, Alioune Niang[1], Vincent Couderc[2], Alessandro Tonello[2], Katarzyna Krupa[1], Mesay Addisu[1], Raphael Jauberteau[1,2], Marc Fabert[2], Daniele Modotto[1], Stefan Wabnitz[3]; [1]*Univ. of Brescia, Italy;* [2]*Univ. of Limoges, France;* [3]*Sapienza Università di Roma, Italy.* We experimentally demonstrate polarization-dependent Kerr spatial beam self-cleaning into the LP11 mode of an Ytterbium-doped multimode optical fiber with parabolic gain and refractive index profiles.

STh4L.2 • 16:45
Multimode Fiber Beam Self-Cleaning in the Anomalous Dispersion Regime, Yann Leventoux[1], Alexandre Parriaux[2], Geoffroy Granger[1], M. Jossent[3], L. Lavoute[3], D. Gaponov[3], Marc Fabert[1], Alessandro Tonello[1], Katarzyna Krupa[2], Agnes Desfarges-Berthelemot[1], Vincent Kermene[1], Oleg Sidelnikov[4], Guy Millot[2], Sebastien Fevrier[1], Stefan Wabnitz[5,4], Vincent Couderc[1]; [1]*Univ. of Limoges, France;* [2]*Univ. of Bourgogne Franche-Comte, France;* [3]*Novae Laser, France;* [4]*Novosibirsk State Univ., Russia;* [5]*Sapienza Università di Roma, Italy.* We experimentally demonstrate Kerr beam self-cleaning of picosecond pulses in the anomalous dispersion regime of graded-index multimode optical fibers, with threshold power reduced by two orders of magnitude with respect to the normal dispersion regime.

STh4L.3 • 17:00
Spatiotemporal Mode-Locking as Multidimensional Optimization, Logan Wright[1], Pavel Sidorenko[1], Zachary Ziegler[1], Andrei Isichenko[1], Boris Malomed[2], Curtis R. Menyuk[3], Demetrios N. Christodoulides[4], Frank W. Wise[1]; [1]*Cornell Univ., USA;* [2]*Dept. of Physical Electronics, School of Electrical Engineering, Faculty of Engineering, and the Center for Light-Matter Interaction, Tel-Aviv Univ., Israel;* [3]*Dept. of Computer Science and Electrical Engineering, Univ. of Maryland Baltimore County, USA;* [4]*CREOL/College of Optics and Photonics, Univ. of Central Florida, USA.* We outline a theoretical framework to understand the multitude of new mode-locked states possible in multi-transverse mode resonators. Full-3D measurements of mode-locked states comprising roughly 30 million modes agree with theoretical expectations.

CLEO: QELS-Fundamental Science

16:30–18:30
FTh4M • Hyperbolic Photonics Media
Presider: Moussa N'Gom Rensselaer Polytechnic Institute, USA

FTh4M.1 • 16:30
Intersubband Plasmons Induced Negative Refraction at mid-IR Frequency in Heterostructured Semiconductor Metamaterials, Mario Ferraro[1], Adrian Hierro[2], Miguel Montes Bajo[2], Julen Tamayo-Arriola[2], Maxime Hugues[1], Jose Ulloa[2], Massimo Giudici[3], Jean Michel Chauveau[1], Patrice Genevet[1]; *[1]CRHEA-CNRS, France; [2]ISOM-Universidad Politécnica de Madrid, Spain; [3]InPhyni-CNRS, France.* We theoretically and experimentally demonstrate negative refraction in a semiconductor system operating at mid-infrared wavelengths. Such effect is generic and realized by electrons quantum confinement in quantum wells, acting as an adjustable resonance.

FTh4M.2 • 16:45
Enhanced Radiative Emission of MQW by Resonant Modes of Hyperbolic Metamaterial Resonator, Kun-Ching Shen[1], Lung-Hsing Hsu[1], Din Ping Tsai[1], Hao-Chung Kuo[2], Chien-Chung Lin[2], Yuh-Jen Cheng[1]; *[1]Academia Sinica, Taiwan; [2]National Chiao Tung Univ., Taiwan.* We report the use of resonant modes of a hyperbolic metamaterial cube made of multiple metal/dielectric layer structure to enhance the radiative emission of multiple quantum wells. The mode analysis and photoluminescence will be discussed.

FTh4M.3 • 17:00
Field Enhancement and Ultrafast Plasmonics In Nonlocal Transitional Metamaterials, Brian Wells[2], Margoth Cordova Castro[3], Anatoly Zayats[3], Viktor A. Podolskiy[1]; *[1]Univ. of Massachusetts Lowell, USA; [2]Univ. of Hartford, USA; [3]King's College London, UK.* We analyze spatial and temporal optical response of plasmonic nanocone arrays, relate the strong enhancement of local intensity to excitation of nonlocal plasmonic modes supported by the composites, and discuss potential applications in ultrafast nonlinear optics and plasmonics.

CLEO: Science & Innovations

16:30–18:30
STh4N • High-Speed Optical Interconnects
Presider: Jonathan Bradley McMaster Univ., Canada

STh4N.1 • 16:30
Demonstration of 80 Gbps NRZ-OOK Electro-Absorption Modulation of InP-on-Si DFB Laser Diodes, Mahmoud Shahin[1], Javad Rahimi Vaskasi[1], Joris van Kerrebrouck[1], Amin Abbasi[2], Kasper Van Gasse[1], Muhammad Muneeb[1], Laurens Breyne[1], Peter Ossieur[1], Xin Yin[1], Johan Bauwelinck[1], Gunther Roelkens[1], Geert Morthier[1]; *[1]Ghent Univ., Belgium; [2]Antwerp space, Belgium.* High-speed electro-absorption modulation of a heterogeneously integrated InP-on-Si DFB laser diode is used for the transmission of an 80 Gbps NRZ-OOK signal over 2 km of NZ-DSF fiber below the hard-decision forward-error-correction threshold.

STh4N.2 • 16:45
Waveguide Integrated CVD Graphene Photo-Thermo-Electric Detector With >40GHz Bandwidth, Simone Marconi[2,1], Vaidotas Miseikis[1,3], Marco Angelo Giambra[1], Alberto Montanaro[1], Vito Sorianello[1], Camilla Coletti[3,4], Marco Romagnoli[1]; *[1]Photonic Networks and Technologies Lab - CNIT, Italy; [2]Tecip Inst. - Scuola Superiore Sant'Anna, Italy; [3]Graphene Labs, Istituto Italiano di Tecnologia, Italy; [4]Center for Nanotechnology Innovation @NEST, Istituto Italiano di Tecnologia, Italy.* We demonstrated a CVD Graphene near-infrared photodetector based on the photo-thermo-electric effect integrated on a Si_3N_4 waveguide. The device is based on a split-gate induced pn junction working at zero bias and with bandwidth >40GHz.

STh4N.3 • 17:00 Invited
Low Power Analog Coherent Links for Next-Generation Datacenters, Clint Schow[1]; *[1]Univ. of California Santa Barbara, USA.* Ever-increasing bandwidth demand in datacenter networks makes a move to coherent links seem inevitable. An "analog coherent" approach using optical phase locked loops can enable low-power consumption, expanded link budgets, low-latency, and future bandwidth scalability.

16:30–18:30
STh4O • Epitaxial Materials & Strain Engineering
Presider: Oana Malis; Purdue Univ., USA

STh4O.1 • 16:30
Transparent Displays Using Strain-Engineered Nanopillar Light-Emitting Diodes, Kunook Chung[1], Jingyang Sui[1], Pei-cheng Ku[1]; *[1]Univ. of Michigan, USA.* Using local strain engineering, we fabricated monolithically integrated and individually addressable RGB pixels and showed feasibility for a transparent microdisplay.

STh4O.2 • 16:45
Uniformly Tensile-strained Germanium Enabled by a Recessed Nitride Stressor for Efficient Integrated Photodetectors at Longer Wavelengths, Yiding Lin[1,2], Danhao Ma[3], Rui-Tao Wen[3], Kwang Hong Lee[2], Xin Guo[1], Jin Zhou[1], Hong Wang[1], Chuan Seng Tan[1,2], Jurgen Michel[2,3]; *[1]Nanyang Technological Univ., Singapore; [2]Low Energy Electronic Systems (LEES), Singapore-MIT Alliance for Research and Technology, Singapore; [3]Materials Science and Engineering, MIT, USA.* Germanium photodetector, formed with a self-aligned dry etching method, together with a tensile silicon nitride sidewall stressor, exhibits a strain profile with improved uniformity and a ~2× enhancement on the quantum efficiency at the *L*-band.

STh4O.3 • 17:00
Ultrawide Strain Tuning of Luminescence from Mechanically Stressed InGaAs Nanomembranes , Xiaowei Wang[1], Xiaorui Cui[2], Abhishek Bhat[2], Donald Savage[2], John Reno[3], Max Lagally[2], Roberto Paiella[1]; *[1]Boston Univ., USA; [2]Univ. of Wisconsin – Madison, USA; [3]Sandia National Labs, USA.* We investigate the tunability of semiconductor light emission based on the use of nanomembranes under external mechanical stress. Active tuning of the InGaAs emission spectrum over an ultrawide wavelength range (> 250 nm) is demonstrated.

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTh4A • New Protocols in Quantum Communications—Continued

FTh4A.3 • 17:15
Genuine Counterfactual Communication with a Nanophotonic Processor, Irati Alonso Calafell[1], Teodor Strömberg[1], David R. Arvidsson-Shukur[2,3], Lee A. Rozema[1], Valeria Saggio[1], Chiara Greganti[1], Nicholas C. Harris[3], Mihika Prabhu[3], Jacques Carolan[3], Michael Hochberg[4], Tom Baehr-Jones[4], Dirk R. Englund[3], Crispin H. Barnes[2], Philip Walther[1]; *[1]Univ. of Vienna, Austria, Austria; [2]Univ. of Cambridge, UK; [3]MIT, USA; [4]Elenion Technologies, USA.* In counterfactual communication particles and information can travel in opposite directions. With our high-fidelity programmable nanophotonic processor we implement the first trace-free counterfactual protocol without post-selection with a counterfactual violation as low as 2.4%.

FTh4A.4 • 17:30
1 GBaud Heterodyne Continuous Variable Quantum Key Distribution over 26 km Fiber, Max Rückmann[1], Christian G. Schäffer[1]; *[1]Radio-Frequency Engineering & Photonics, Helmut-Schmidt-Univ., Germany.* We experimentally demonstrate a 1 GBaud heterodyne continuous variable quantum key distribution system based on standard telecom components capable to achieve a key rate of 1.71 Mbit/s over 26 km of fiber.

FTh4B • Non-Diffractive & Vortex Beams—Continued

FTh4B.4 • 17:15
Abruptly Focusing X-waves: Nondiffracting Waves with Localized Disruptions, Liang Jie Wong[1], Ido Kaminer[2]; *[1]SIMTech, Singapore; [2]Technion, Israel.* We present a family of electromagnetic wavepackets with nondiffracting behavior for most of their propagation, but are capable of extremely strong focusing behavior at specified locations, enhancing their peak intensity by over 200 times.

FTh4B.5 • 17:30
Optimization of Higher-Order Transverse Modes of Cylindrical Vector Beams for Enhanced Spatial Resolution in Image Subtraction, Mio Yoshida[1], Yuichi Kozawa[1,2], Shunichi Sato[1]; *[1]Tohoku Univ., Japan; [2]JST PRESTO, Japan.* We demonstrate the enhancement of spatial resolution of subtraction imaging in confocal laser scanning microscopy utilizing radially and azimuthally polarized, higher-order mode beams. The spatial resolution close to 100 nm is experimentally achieved.

FTh4C • Advanced Nanophotonic Platforms for Spectroscopy & Sensing—Continued

FTh4C.3 • 17:15
Near-Field Tomography and Spectroscopy of Surface States on a Three-Dimensional Topological Insulator, Fabian Sandner[1], Fabian Mooshammer[1], Markus A. Huber[1], Martin Zizlsperger[1], Helena Weigand[1], Markus Plankl[1], Christian Weyrich[2], Martin Lanius[2], Jörn Kampmeier[2], Gregor Mussler[2], Detlev Grützmacher[2], Jessica L. Boland[1], Tyler L. Cocker[3], Rupert Huber[1]; *[1]Dept. of Physics, Univ. of Regensburg, Germany; [2]Peter Grünberg Institut 9, Forschungszentrum Jülich, Germany; [3]Dept. of Physics and Astronomy, Michigan State Univ., USA.* Beside massless Dirac fermions, topological insulator surfaces can host a massive two-dimensional electron gas. Using near-field spectroscopy, we identify both of these surface states by retrieving the nanoscale dielectric function without any model assumptions.

FTh4C.4 • 17:30
Graphene Modified Plasmonic Guided Mode For CO_2 Detection, Thomas M. Kananen[1], Anishkumar Soman[1], Arnav Malkani[1], Zi Wang[1], Bingjun Xu[1], Tingyi Gu[1]; *[1]Univ. of Delaware, USA.* We observed broadening of the plasmonic guided modes in gold nanorod arrays by a single layer graphene, which can manifest CO_2 detection. The plasmonic modes enhance absoprtion by over 35% from 729 to 621 cm^{-1}.

FTh4D • Beyond Photon Pairs—Continued

FTh4D.4 • 17:30
Non-Gaussian Continuous-Variable Graph States, Mattia Walschaers[1], Valentina Parigi[1], Nicolas Treps[1]; *[1]Laboratoire Kastler Brossel, France.* Mode-tunable photon subtraction is a viable method to introduce non-Gaussian features in continuous-variable graph states. Non-Gaussian properties are shown to spread up to next-to-nearest neighbours of the graph's vertex in which the photon was subtracted.

STh4E • Ultrafast Parametric Sources II—Continued

STh4E.4 • 17:30
Broadband, Near Single-Cycle, Waveform-Stable Mid-Infrared Pulses Driven by a 2-µm Femtosecond Source, Thomas P. Butler[1], Daniel Gerz[1,2], Christina Hofer[1,2], Jia Xu[1], Christian Gaida[3], Tobias Heuermann[3,4], Martin Gebhardt[3,4], Lenard Vamos[2], Wolfgang Schweinberger[2,5], Julia Gessner[1,2], Thomas Seifke[3,6], Martin Heusinger[3], Uwe Zeitner[3,7], Alexander Apolonski[1,2], Jens Limpert[3,4], Ferenc Krausz[1,2], Ioachim Pupeza[1,2]; *[1]Max Planck Insititute of Quantum Optics, Germany; [2]Dept. of Physics, Ludwig Maximillian Univ. Munich, Germany; [3]Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ. Jena, Germany; [4]Helmholtz Inst. Jena, Germany; [5]Dept. of Physics and Astronomy, King Saud Univ., Saudi Arabia; [6]Physikalisch-Technische Bundestalt, Germany; [7]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present a novel source of ultrashort, watt-scale, 50-MHz repetition-rate, broadband (6–18 µm, or 555–1666 cm^{-1}) pulses. Generation and electro-optic-sampling of the waveform-stable transients is driven with a femtosecond thulium-based fiber-amplifier.

JTh4F • Interaction of Strong THZ Fields with Condensed Matter Systems—Continued

JTh4F.3 • 17:30
Higgs Spectroscopy and Control of Non-Equilibrium Phases in Superconductors by Terahertz Light-Induced Supercurrent Injection, Martin Mootz[1], Ilias E. Perakis[1], Xu Yang[2], Chirag Vaswani[2], Liang Luo[2], Jigang Wang[2]; *[1]Physics, Univ. of Alabama at Birmingham, USA; [2]Physics and Astronomy, Iowa State Univ. and Ames Lab, USA.* The non-equilibrium dynamics of superconductors after ultrafast terahertz excitation is analyzed. Excitation of selective non-equilibrium phases and detection of Higgs mode in the nonlinear response are demonstrated by inducing supercurrents via terahertz pulse shaping.

STh4G • Opto-mechanics—Continued

STh4G.4 • 17:15
Achieving sub-femtometer displacement sensitivity in integrated ultrahigh-Q crystalline microcavities via Pound-Drever-Hall, Yoon-Soo Jang[1], JinKang Lim[1], Seung-Woo Kim[2], Wei Liang[3], Andrey B. Matsko[3], Lute Maleki[3], Chee Wei Wong[1]; *[1]UCLA, USA; [2]KAIST, South Korea (the Republic of); [3]OEwaves, USA.* We present real-time and wide dynamic range measurement of sub-femtometer scale displacement of micro-cavity. We achieve power spectral density of displacement on the MgF_2 whispering gallery mode(WGM) microcavity with sub-femtometer displacement sensitivity.

STh4G.5 • 17:30
All-Fiber Phase-Shifted Demodulation System for Fabry-Perot Interferometric Sensors, Yun Liu[1], Bing Qi[1], Drew Winder[1]; *[1]Oak Ridge National Lab, USA.* A quadrature phase-shifted optical demodulation scheme has been developed for low-coherence fiber-optic Fabry-Perot interferometric sensors. The demodulator shows a great stability of phase shift. Applications to vibration/strain measurements are demonstrated.

STh4H • Optical Driven Photonics—Continued

STh4H.3 • 17:15
Light and Microwaves in Laser Frequency Combs: An Interplay of Spatio-Temporal Phenomena, Marco Piccardo[1], Dmitry Kazakov[1], Benedikt Schwarz[2,1], Paul Chevalier[1], Arman Amirzhan[1], Yongrui Wang[3], Feng Xie[4], Kevin Lascola[4], Steffen Becker[5], Lars Hildebrandt[5], Robert Weih[5], Alexey Belyanin[3], Federico Capasso[1]; *[1]Harvard Univ., USA; [2]TU Wien, Austria; [3]Texas A&M, USA; [4]Thorlabs Quantum Electronics, USA; [5]Nanoplus Nanosystems and Technologies GmbH, Germany.* The study of the interaction between light and microwaves in laser frequency combs reveals novel spatio-temporal dynamic phenomena and allows for new hybrid optical-microwave devices.

STh4H.4 • 17:30
Saturation Effects in Laser Cooling of Crystals, Long Cheng[1], Laura B. Andre[1], Alexander J. Salkeld[1], Stephen C. Rand[1]; *[1]Univ. of Michigan, USA.* Record laser cooling of Yb:YAG and Yb:KYW under ambient conditions is reported and compared quantitatively with analysis indicating that cooling power can theoretically be improved substantially by saturating the impurity absorption.

Meeting Room 211 A/B

CLEO: Applications & Technology

ATh4I • A&T Topical Review on Silicon Photonics II—Continued

ATh4I.3 • 17:15 Invited
Coherent Silicon Photonic Devices for Communication and Sensing, Chris Doerr[1]; [1]*Acacia Communications Inc, USA.*Abstract not available.

Meeting Room 211 C/D

CLEO: Science & Innovations

STh4J • Applications of Lasers & Microcombs—Continued

STh4J.4 • 17:30
Dual-polarization frequency combs in a single Kerr microcavity via single-pumped mode-crossing, Qingsong Bai[1], Jinghui Yang[1], Hao Liu[1], Mingbin Yu[2,3], Dim Lee Kwong[2], Dong Hou[4], Chee Wei Wong[1]; [1]*Univ. of California Los Angeles, USA;* [2]*Inst. of Microelectronics, Singapore;* [3]*Shanghai Inst. of Microsystem and Information Technology, China;* [4]*School of Automation Engineering, Univ. of Electronic Science and Technology of China, China.* We report dual-polarization Kerr frequency combs generated in a single microcavity by a single pump through mode-crossing effect engineering. Both of the combs can be driven to phase-locked state, with slightly different mode spacing.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATh4K • Sources & Techniques for Industrial Monitoring—Continued

ATh4K.4 • 17:15
Diode Laser-based Film Thickness Measurement of DEF in a generic exhaust gas test bench for the investigation of SCR-relevant processes, Anna Schmidt[1], Benjamin Kühnreich[1], Matthias Jacob[1], Steven Wagner[1]; [1]*Technische Universität Darmstadt, Germany.* An absorption based laser sensor for film thickness measurement of DEF in an exhaust gas test bench is presented. A wavelength pre-selection ensures that film-thicknesses could be measured without cross sensitivity to temperature or concentration.

ATh4K.5 • 17:30 Invited
Diode Laser Spectroscopy for Optimization of Boilers, Furnaces and Flares, Andrew D. Sappey[1,2]; [1]*Zolo Technologies, Inc., USA;* [2]*John Zink Company, USA.* We have employed tunable diode laser spectroscopy for nearly 15 years enabling optimziation of large combustion-driven assets ranging from coal-fired boilers to electric arc furnaces for steel recycling. Here, we review some important results.

Meeting Room 212 C/D

CLEO: Science & Innovations

STh4L • Multi-Mode Fiber Phenomena II—Continued

STh4L.4 • 17:15
Cascaded Raman lasing in a multimode diode-pumped graded-index fiber, Sergey A. Babin[1,2], Ekaterina A. Evmenova[1], Alexey G. Kuznetsov[1], Ilya N. Nemov[1], Alexey Wolf[1,2], Alexandr V. Dostovalov[1,2], Sergey I. Kablukov[1], Evgeniy V. Podivilov[1,2]; [1]*Inst. of Automation and Electrometry, Russia;* [2]*Novosibirsk State Univ., Russia.* Multimode 915-nm diode pumped 1.1-km graded-index fiber is able to generate high-quality (M^2~1.6) 2nd-order Stokes beam at 978-996 nm with high power/slope efficiency (~30W/70%) provided by combination of FBG cavity and random distributed feedback.

STh4L.5 • 17:30 Invited
Controlling Nonlinearity in Multimode Fibers and Fast Real-Time Wave-Front Shaping, Omer Tzang[1], Eyal Niv[1], Dan Feldkhun[1], Antonio Caravaca[1], Sakshi Singh[1], Simon Labouesse[1], Kelvin Wagner[1], Rafael Piestun[1]; [1]*Univ. of Colorado at Boulder, USA.* We show adaptive computational control of complex and non-linear interactions in multimode fibers. We also present novel wave-front shaping methodologies that are orders of magnitude faster than other technologies, and show real-time continues operation.

CLEO: QELS-Fundamental Science

FTh4M • Hyperbolic Photonics Media—Continued

FTh4M.4 • 17:15
Nano-scale Hyperbolic Metamaterial cavity system for enhanced Light-Matter interaction at Visible Frequencies, Sita Rama Krishna C. Indukuri[1], Jonathan Bar-David[1], Noa Mazurski[1], Uriel Levy[1]; [1]*Hebrew Univ. of Jerusalem., Israel.* We design and demonstrate experimentally nano-scale hyperbolic metamaterial cavities at the visible frequency to enhance the free space radiation power of quantum dots for applications in solid state light emitting devices.

FTh4M.5 • 17:30
Quantum to Classical Transitions in Multilayer Plasmonic Metamaterials, Evan L. Simmons[1], Kun Li[2], Andrew Briggs[2], Seth Bank[2], Daniel Wasserman[2], Evgenii Narimanov[3], Viktor Podolskiy[1]; [1]*Physics, Univ. of Massachusettes Lowell, USA;* [2]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA;* [3]*Electrical and Computer Engineering, Purdue Univ., USA.* We demonstrate that classical-to-quantum transition of free electron plasma can be used to as a doping-independent parameter controlling optical topology of metamaterials and present a comprehensive description of this phenomenon.

CLEO: Science & Innovations

STh4N • High-Speed Optical Interconnects—Continued

STh4N.4 • 17:30
All-Plasmonic 100 GBd Optical Communication Link, Yannick Salamin[1], Ping Ma[1], Benedikt Baeuerle[1], Wolfgang Heni[1], Claudia Hoessbacher[1], Arne Josten[1], Yuriy Fedoryshyn[1], Alexandros Emboras[1], Delwin L. Elder[2], Larry R. Dalton[2], Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland;* [2]*Dept. of Chemistry, Univ. of Washington, USA.* We realize an all-plasmonic optical communication link operating at 100 Gbit/s NRZ, in which the optical transmitter and receiver rely on a plasmonic-organic modulator and a plasmonic-graphene photodetector, respectively.

STh4O • Epitaxial Materials & Strain Engineering—Continued

STh4O.4 • 17:15
RF Read-Out of Minority Carrier Lifetimes in Micro-Scale Infrared Materials, Sukrith Dev[1], Yinan Wang[1], Kyounghwan Kim[1], Marziyeh Zamiri[2], Clark Kadlec[3], Michael Goldflam[3], Samuel Hawkins[3], Eric Shaner[3], Jin Kim[3], Sanjay Krishna[4], Monica Allen[5], Jeffery Allen[5], Emanuel Tutuc[1], Daniel Wasserman[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Univ. of Wisconsin , USA;* [3]*Sandia National Labs, USA;* [4]*Ohio State Univ., USA;* [5]*Eglin Air Force Base, USA.* We present micro-scale time-resolved microwave resonator response (μ-TRMRR), a sensitive technique capable of measuring carrier lifetimes in micron-scale materials, something not typically achievable using common techniques like time-resolved photoluminescence or time-resolved microwave reflectance.

STh4O.5 • 17:30 Invited
Germanium-Tin Semiconductors for Silicon-Compatible Mid-Infrared Photonics, Simone Assali[1], Anis Attiaoui[1], Étienne Bouthillier[1], Patrick Del Vecchio[1], Aashish Kumar[1], Samik Mukherjee[1], Jérôme Nicolas[1], Oussama Moutanabbir[1]; [1]*Engineering Physics, Ecole Polytechnique de Montreal, Canada.* GeSn alloys have recently been the subject of extensive investigations as a new platform to engineer the band structure in group IV semiconductors thus providing a rich playground to implement silicon-compatible photonics and optoelectronics. Herein, we discuss the growth of these metastable semiconductors and their use in of silicon-compatible devices. We will also discuss the effects of strain and Sn content on the optical, electronic, and structural properties of GeSn semiconductors.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FTh4A • New Protocols in Quantum Communications—Continued

FTh4A.5 • 17:45
A Continuous-Variable Quantum Repeater based on Quantum Scissors, Kaushik P. Seshadreesan[1], Hari Krovi[2], Saikat Guha[1]; [1]*College of Optical Sciences, Univ. of Arizona, USA;* [2]*Quantum Engineering and Computing Physical Sciences and Systems, Raytheon BBN Technologies, USA.* Using the quantum scissors operation for entanglement distillation and a single-rail Bell state projection for non-Gaussian entanglement swapping, we show a multiplexed quantum repeater scheme for continuous-variable entanglement distribution over a pure loss communication channel.

FTh4A.6 • 18:00
Experimental demonstration of all-photonic quantum repeater, Zheng-Da Li[1], Rui Zhang[1], Xu-Fei Yin[1], Li-Zheng Liu[1], Yi Hu[1], Yu-Qiang Fang[1], Yue-Yang Fei[1], Xiao Jiang[1], Jun Zhang[1], Feihu Xu[1], Yu-ao Chen[1], Jian-Wei Pan[1]; [1]*Univ. of Science and Technology of China, China.* We for the first time demonstrate the all-photonic quantum repeater by manipulating a 12-photon interferometry. Our experiment opens a new window of opportunity for a memoryless quantum repeater with efficient photonic graph states.

FTh4B • Non-Diffractive & Vortex Beams—Continued

FTh4B.6 • 17:45
Ultrafast tunable mid-infrared higher-order optical vortex source, Varun Sharma[1], S Chaitanya Kumar[2], Goutam Samanta[1], M Ebrahim-Zadeh[3,4]; [1]*PRL Ahmedabad, India;* [2]*Radiantis, Polígon Camí Ral, 08850 Gavà,, Spain;* [3]*ICFO-Institut de Ciencies Fotoniques, The Barcelona Inst. of Science and Technology, Spain;* [4]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report on the generation of tunable ultrafast, mid-infrared, multi-order, optical vortices from a picosecond singly-resonant optical parametric oscillator in 2493-4035 nm wavelength range with an average output power of up to 800 mW.

FTh4B.7 • 18:00
Optical Clearing and Shielding with Fan-shaped Vortex Beams, Haiping Wang[1], Jina Ma[1], Xiuyan Zheng[1], Liqin Tang[1,2], Daohong Song[1,2], Yi Hu[1,2], Yigang Li[1,2], Zhigang Chen[1,2]; [1]*Nankai Univ., China;* [2]*Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China.* We propose and demonstrate a new kind of spiral vortex beams by phase engineering. Such fan-shaped optical beams can be effectively controlled and utilized for optical clearing and shielding of target particles in turbulent environments.

FTh4B.8 • 18:15
Evolution and Conservation of Orbital Angular Momentum in Three-Dimensional Structured Light, Ahmed Dorrah[1], Carmelo Rosales-Guzm\'an[2], Andrew Forbes[2], Mo Mojahedi[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [2]*School of Physics, Univ. of the Witwatersrand, South Africa.* We engineer quasi 3D structured light fields in which the orbital angular momentum changes locally in both sign and magnitude along the beam's axis and explain how such transitions occur without violating conservation of angular momentum.

FTh4C • Advanced Nanophotonic Platforms for Spectroscopy & Sensing—Continued

FTh4C.5 • 17:45
2D Perovskite-Based Metasurfaces for Enhanced Plasmonic Sensing, Shuwen Zeng[1,2], Guozhen Liang[2], Alexandre Gheno[1], Sylvain Vedraine[1], Nanfang Yu[2]; [1]*French National Centre for Scientific Research (CNRS), France;* [2]*Columbia Univ., USA.* We demonstrated a surface plasmon resonance sensor based on 2D Perovskite and Goos-Hänchen shift exhibiting sensitivity up to 900,000 um/RIU for refractive index sensing of target analytes.

FTh4C.6 • 18:00
Enhanced Circular Dichroism and Chiral Sensing with Bound States in the Continuum, Kirill Koshelev[1,2], Yasaman Jahani[3], Andreas Tittl[3], Hatice Altug[3], Yuri S. Kivshar[1,2]; [1]*Australian National Univ., Australia;* [2]*Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia;* [3]*Bioengineering Dept., Ecole Polytechnique Federale de Lausanne, Switzerland.* We reveal that optical chirality at the nanoscale can be boosted dramatically by bound states in the continuum (BIC). We predict the enhancement of chiroptical signals from nanostructures supporting quasi-BICs in mid-IR with a record-high efficiency.

FTh4C.7 • 18:15
Electrical Detection of Surface Plasmons for Sensing Applications, Tejaswini Ronur Praful[1], David W. Keene[1], Natalia Noginova[1]; [1]*Norfolk State Univ., USA.* Photoinduced voltages in metal films with rectangular profile modulation demonstrate sharp polarity switching at plasmon resonance conditions. We explore this effect for applications for compact plasmonic sensors with electrical detection.

FTh4D • Beyond Photon Pairs—Continued

FTh4D.5 • 17:45
Experimental preparation of Gottesman-Kitaev-Preskill states by photon-number-resolving detection, Miller Eaton[1], Rajveer Nehra[1], Olivier Pfister[1]; [1]*Univ. of Virginia, USA.* We propose to expand "Fock state filtering" to photon-number-resolving detection and apply it to the generation of displaced single-photon states, cat states, and Gottesman-Kitaev-Preskill ancillas.

FTh4D.6 • 18:00
Beyond Photon Pairs: Nanophotonic Photon Number Difference Squeezing, Reihaneh Shahrokhshahi[1], Blair Morrison[1], Matthew J. Collins[1], Luke G. Helt[1], Nicolas Quesada[1], Dylan H. Mahler[1], Kang Tan[1], Varun D. Vaidya[1], Alain Repingon[1], Jonathan Lavoie[1], Raphael C. Pooser[2], Adriana Lita[3], Sae Woo Nam[3], Thomas Gerrits[3], Zachary Vernon[1]; [1]*Xanadu Quantum Technologies Inc, Canada;* [2]*Oak Ridge National Labs, USA;* [3]*National Inst. of Standards and Technology, USA.* We demonstrate over 1 dB of photon number difference correlations from two-mode squeezed states having mean photon number above 5, generated with a silicon nitride ring resonator and measured using photon number-resolving transition edge sensors.

18:30–20:00 Emerging Trends in Nonlinear Optics - A Review of CLEO: 2019, *Room 230A*

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

Executive Ballroom 210E

CLEO: Science & Innovations

STh4E • Ultrafast Parametric Sources II—Continued

STh4E.5 • 17:45
Near-single-cycle long-wave infrared pulses for coherent linear and nonlinear optics, Abijith Kowligy[1,3], Henry Timmers[1], Alexander Lind[1,3], Sylvain Karlen[5,1], Flavio C. Cruz[1,3], Peter G. Schunemann[2], Jens Biegert[4], Scott A. Diddams[1,3]; [1]*NIST, USA;* [2]*BAE Systems, USA;* [3]*Physics, Univ. of Colorado, USA;* [4]*ICFO, Spain;* [5]*CSEM, Switzerland.* We generate and detect phase-stable, near-single-cycle long-wave-infrared pulses using intrapulse difference-frequency generation and dual frequency comb electro-optic sampling, respectively. Applications such as high-resolution, super-octave spectroscopy and parametric amplification are described.

STh4E.6 • 18:00
Octave-Spanning Mid-Infrared Intrapulse Difference Frequency Generation With A Few-Cycle Cr:ZnS Laser, Sergey Vasilyev[1], Igor S. Moskalev[1], Viktor O. Smolski[1], Jeremy Peppers[1], Mike Mirov[1], Andrey V. Muraviev[2], Kevin T. Zawilski[3], Peter G. Schunemann[3], Sergey Mirov[1,4], Konstantin L. Vodopyanov[2], Valentin P. Gapontsev[5]; [1]*IPG Photonics - Southeast Technology Center, USA;* [2]*CREOL, Univ. of Central Florida, USA;* [3]*BAE Systems, USA;* [4]*Dept. of Physics, Univ. of Alabama at Birmingham, USA;* [5]*IPG Photonics Corporation, USA.* We generate longwave mid-IR transients between 4 and 18 µm via optical rectification of 5.9-W 78-MHz 20-fs laser pulses centered at 2.5 µm. We achieve 0.15 W (0.014 W) average power in ZGP (GaSe) crystals.

Executive Ballroom 210F

Joint

JTh4F • Interaction of Strong THZ Fields with Condensed Matter Systems—Continued

JTh4F.4 • 17:45
Terahertz Kerr Effect in β-Alumina Ion Conductors, Andrey D. Poletayev[1], Matthias C. Hoffmann[2], Samuel Teitelbaum[2], Mariano Trigo[2], William Chueh[1], Aaron Lindenberg[1,2]; [1]*Materials Science & Engineering, Stanford Univ., USA;* [2]*Stanford Linear Accelerator Lab, USA.* We present THz Kerr effect spectra of Na, K, and Ag β-alumina solid-state ion conductors as model systems for grid-scale battery applications. We show both a field-following response consistent with electronic polarization, and a slower relaxation consistent with translation of mobile ions.

JTh4F.5 • 18:00
Measurement of Quadratic Terahertz Optical Nonlinearities Using Second-Harmonic Lock-in Detection, Shuai Lin[1], Shukai Yu[1], Diyar Talbayev[1]; [1]*Tulane Univ., USA.* We demonstrate a method to measure quadratic terahertz optical nonlinearities in terahertz time-domain spectroscopy by measuring the quadratic terahertz Kerr effect in a (110) GaP crystal in the presence of strong linear electro-optic Pockels effect.

FTh4F.6 • 18:15
Withdrawn

Executive Ballroom 210G

CLEO: Science & Innovations

STh4G • Opto-mechanics—Continued

STh4G.6 • 17:45
Quantum Enhancement of Advanced LIGO Detector Using Squeezed Vacuum States, Maggie Tse[1]; [1]*LIGO MIT, USA.* The Advanced LIGO detector measures the distortion of spacetime from gravitational waves using Michelson interferometers. By injecting a squeezed vacuum state, we have demonstrated shot noise reduction, which enhanced the sensitivity of the LIGO detector.

STh4G.7 • 18:00
Thermo-mechanically Squeezed Graphene Amplifier, Rajan Singh[1], Ryan J. Nicholl[2], Kirill Bolotin[3], Saikat Ghosh[1]; [1]*Indian Inst. of Technology, Kanpur, India;* [2]*Vanderbilt Univ., USA;* [3]*Freie Universität Berlin, Germany.* We demonstrate coupling of mechanical mode of graphene resonator to that of Silicon Nitride resonator, resulting in 38 dB gain. Furthermore, with thermomechanical squeezing of graphene thermal noise, we demonstrate an overall measurement sensitivity of 3.8 $fmHz^{-1/2}$.

Executive Ballroom 210H

STh4H • Optical Driven Photonics—Continued

STh4H.5 • 17:45
Bright and Ultrafast Photoelectron Emission from Aligned Single-Wall Carbon Nanotubes through Multiphoton Exciton Resonance, Derek A. Bas[2,1], Mark E. Green[3], Hsin-Yu Yao[4], Jamie J. Gengler[2,5], Robert J. Headrick[6], Tyson C. Back[2], Augustine M. Urbas[2], Matteo Pasquali[6], Junichiro Kono[7], Tsing-Hua Her[3]; [1]*Azimuth Corporation, USA;* [2]*Materials and Manufacturing Directorate, Air Force Research Lab, USA;* [3]*Dept. of Physics and Optical Science, UNC Charlotte, USA;* [4]*Yonghe Dist., Taiwan;* [5]*UES, Inc., USA;* [6]*Dept. of Chemical & Biomolecular Engineering, Dept. of Chemistry, Dept. of Materials Science and NanoEngineering, Rice Univ., USA;* [7]*Dept. of Materials Science and NanoEngineering, Dept. of Electrical and Computer Engineering, Dept. of Physics and Astronomy, Rice Univ., USA.* We report ultrafast photoelectron emission from aligned single-wall carbon nanotubes utilizing strong exciton resonances inherent in this prototypical one-dimensional material. These results establish SWCNT films as novel and promising ultrafast photocathode material.

STh4H.6 • 18:00
Optical Tuning of Graphene Electronics and Plasmonics on Iron Doped Lithium Niobate, Jon Gorecki[2], Lewis Piper[1], Vasilis Apostolopoulos[1], Sakellaris Mailis[2], Nikitas Papasimakis[2]; [1]*School of Physics and Astronomy, Univ. of Southampton, UK;* [2]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We demonstrate nonvolatile, but reversible, optical control of charge carriers in graphene by virtue of a photorefractive iron doped lithium niobate substrate which leads to tunable electronic and plasmonic devices.

STh4H.7 • 18:15
Strong coupling of Excitons in WS_2 with Fano Resonances in Photonic Crystals, Rezlind Bushati[1,2], Sriram Guddala[1], Vinod Menon[2,1]; [1]*Physics, CUNY Graduate Center, USA;* [2]*Physics, CUNY City College, USA.* We report strong coupling between excitons in monolayer WS_2 and Fano resonances in a dielectric photonic crystal. This gives rise to a Rabi splitting of ~25 meV at room temperature in an open cavity geometry.

18:30–20:00 Emerging Trends in Nonlinear Optics - A Review of CLEO: 2019, *Room 230A*

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

Meeting Room 211 A/B

CLEO: Applications & Technology

ATh4I • A&T Topical Review on Silicon Photonics II—Continued

ATh4I.4 • 17:45
Beam-Steering Nanophotonic Phased-Array Neural Probes, Wesley D. Sacher[1], Xinyu Liu[1], Fu-Der Chen[2], Homeira Moradi-Chameh[3], Ilan Felts Almog[2], Thomas Lordello[2], Michael Chang[3], Azadeh Naderian[3], Trevor Fowler[1], Eran Segev[1], Tianyuan Xue[2], Sara Mahallati[3], Taufik Valiante[3,4], Laurent Moreaux[1], Joyce K. Poon[2,5], Michael L. Roukes[1]; [1]*Division of Physics, Mathematics, and Astronomy, California Inst. of Technology, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [3]*Division of Fundamental Neurobiology, Krembil Research Inst., Canada;* [4]*Division of Neurosurgery, Univ. of Toronto, Canada;* [5]*Max Planck Inst. for Microstructure Physics, Germany.* We demonstrate the first implantable nanophotonic neural probes with integrated silicon nitride phased arrays. Coherent beam-steering is achieved in brain tissue by wavelength tuning. Beam profiles, optogenetic stimulation, and functional imaging are validated *in vitro*.

ATh4I.5 • 18:00 Invited
Optical Phased Array Beam-steering with a Large Steering Angle and a Tailored Envelope. Linjie Zhou[1], Weihan Xu[1], Liangjun Lu[1], and Jianping Chen[1]; [1]*Shanghai Jiao Tong University, China.* We demonstrate an SOI-based OPA with a curved waveguide array for inter-channel coupling suppression. The far-field diffraction pattern exhibits a plateau envelope, caused by the Fabry-Perot effect from a silica cavity at the emitting end.

Meeting Room 211 C/D

CLEO: Science & Innovations

STh4J • Applications of Lasers & Microcombs—Continued

STh4J.5 • 17:45
Electrically tunable Kerr combs in graphene-nitride microresonators on-chip, Baicheng Yao[1,2], Abhinav Kumar Vinod[2], Shu-Wei Huang[2], Yuan Liu[2], Jaime G. Flor Flores[2], Chanyeol Choi[2], Yu Huang[2], Xiangfeng Duan[2], Chee Wei Wong[2]; [1]*Univ of Electronic Science & Tech China, China;* [2]*Univ. of California, Los Angeles, USA.* Dynamic tuning of soliton combs is achieved in graphene actuated SiN microresonators. Driven by single-volt-voltage gating, optical dispersion of the microcavity is controlled, enabling broadband tuning of comb spectrum and diversity of soliton crystal generations.

STh4J.6 • 18:00
Ultrahigh-Q Crystalline Microresonator Fabricated with Computer-controlled Machining without Polishing, Shun Fujii[1], Mika Fuchida[1], Hikaru Amano[1], Ryo Suzuki[1], Yasuhiro Kakinuma[1], Takasumi Tanabe[1]; [1]*Keio Univ., Japan.* We fabricated crystalline whispering gallery mode microresonators with an ultrahigh-Q close to 10^8 without polishing by employing a computer-controlled ultraprecision machining process.

STh4J.7 • 18:15
High Stability Self-Injection Locked Laser, Anatoliy Savchenkov[1], Skip Williams[1], Andrey B. Matsko[1]; [1]*OEwaves Inc, USA.* We demonstrate a self-injection locked 1550nm laser characterized with Allan deviation of 10^{-12} at 1s. The stability is achieved using a composite crystalline monolithic optical resonator. The thermal stabilization on the order of 10uK at 1s is achieved using a standard thermo-electric element.

Meeting Room 212 A/B

CLEO: Applications & Technology

ATh4K • Sources & Techniques for Industrial Monitoring—Continued

ATh4K.6 • 18:00
Acousto-Optically Modulated Quantum Cascade Laser (AOM QCL) for Combustion and Detonation Thermometry, Zachary Loparo[1,2], Kyle Thurmond[1], Erik Ninnemann[1], Andrew Laich[1], Ahmad Azim[2,3], Arkadiy Lyakh[2,3], Subith S. Vasu[1,2]; [1]*Mechanical and Aerospace Engineering, Univ. of Central Florida, USA;* [2]*CREOL, College of Optics and Photonics, Univ. of Central Florida, USA;* [3]*NanoScience Technology Center, Univ. of Central Florida, USA.* We demonstrate temperature measurements in shock-heated mixtures of carbon monoxide (CO) using an acousto-optically modulated quantum cascade laser. Temperatures between 900 – 1300 K were measured at rates up to 250 kHz.

ATh4K.7 • 18:15
Design of next-generation tunable ECDLs based on MEMS, Morten Hoppe[1], Hanna Rohling[1], Sebastian Schmidtmann[2], Herve Tatenguem Fankem[1], Tobias Milde[1], Joachim R. Sacher[1,2]; [1]*Sacher Lasertechnik GmbH, Germany;* [2]*Sensor Photonics GmbH, Germany.* An External Cavity Diode Laser (ECDL) design of next-generation based on Micro Electro Mechanical System (MEMS) is presented. The excellent results in respect of tuning speed and range as well as repeatability are shown.

Meeting Room 212 C/D

CLEO: Science & Innovations

STh4L • Multi-Mode Fiber Phenomena II—Continued

STh4L.6 • 18:00
Passive Q-switching Based on Nonlinear Effect of Multimode Interference in Tapered Fiber, Hanieh Afkhamiardakani[1], Jean-Claude Diels[1]; [1]*CHTM, Univ. of New Mexico, USA.* A novel method to passively Q-switch an all-PM fiber laser is presented. A tapered fiber (free standing in air) is used as a saturable absorber based on Kerr effect of multimode interference in tapered section.

18:30–20:00 Emerging Trends in Nonlinear Optics - A Review of CLEO: 2019, *Room 230A*

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

FTh4M • Hyperbolic Photonics Media—Continued

FTh4M.6 • 17:45
Development of Near-Infrared Rare Earth Doped Organic Materials for Nanophotonics Applications, Joshua K. Asane[1], Alexis Bullock[2], Marvin Clemmons[1], Natalia Noginova[1], Mikhail Noginov[1]; [1]*Norfolk State Univ., USA.* We have synthesized a series of near-infrared rare-earth doped organic materials for nanophotonics applications and studied their absorption and emission properties. The developed materials show promise as research tools and (meta)device components.

FTh4M.7 • 18:00
Spontaneous emission from a wide quantum electron, Aviv Karnieli[1], Roei Remez[1], Sivan Trajtenberg-Mills[1], Niv Shapira[1], Ido Kaminer[2], Yossi Lereah[1], Ady Arie[1]; [1]*Tel Aviv Univ. , Israel;* [2]*Technion, Israel.* We show that the azimuthal distribution of emitted light in the Smith-Purcell interaction does not depend on the width of the electron wavefunction, thus providing direct evidence for the probabilistic interpretation of the electron wavefunction.

FTh4M.8 • 18:15
Probe the ultimate nonlocal limit of 'threshold-free' Cherenkov radiation, Hao Hu[1], Xiao Lin[1], Dongjue Liu[1], Patrice Genevet[2], Baile Zhang[1], Yu Luo[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*CNRS, France.* Here we probe the ultimate nonlocal limit of "threshold-free" Cherenkov radiation in hyperbolic metamaterials. The nonlocality, induced by the spatial dispersion from the inhomogeneous structure and the electron screening, determines a nonzero Cherenkov threshold.

Marriott
Salon III

Marriott
Salon IV

CLEO: Science & Innovations

STh4N • High-Speed Optical Interconnects—Continued

STh4N.5 • 18:00
A 10Gb/s Optical Random-Access Memory using a saturated SOA-MZI fast Access Gate and a monolithic InP Flip-Flop, Apostolos Tsakyridis[1], Christos Vagionas[1], Theoni Alexoudi[1], Amalia Miliou[1], Nikos Pleros[1]; [1]*Aristotle Univ. of Thessaloniki, Greece.* We experimentally demonstrate an all-optical static Random-Access Memory (RAM) cell using a monolithic integrated InP Flip-Flop and a fast strongly-saturated push-pull SOA-MZI Access-Gate, reporting 10Gb/s error-free Write/Read operation and the fastest RAM cell to date.

STh4N.6 • 18:15
Silicon Photonic Single-Sideband Generation with Dual-Parallel Mach-Zehnder Modulators, Ashok Kodigala[1], Michael R. Gehl[1], Christopher DeRose[1], Dana Hood[1], Andrew T. Pomerene[1], Christina Dallo[1], Douglas Trotter[1], Penny Moore[1], Andrew Starbuck[1], Jongmin Lee[1], Grant Biedermann[1], Anthony Lentine[1]; [1]*Sandia National Labs, USA.* We demonstrate the first silicon photonic single-sideband (SSB) modulator with dual-parallel Mach-Zehnder modulators (MZMs) operating near 1550 nm with a measured carrier suppression of 27 dB and at least 12 dB sideband suppression at 1 GHz.

STh4O • Epitaxial Materials & Strain Engineering—Continued

STh4O.6 • 18:00
Study of High Performance GeSn Photodetectors with Cutoff Wavelength up to 3.7 µm for Low-Cost Infrared Imaging, Huong Tran[1], Thach Pham[1], Joe Margetis[2], Yiyin Zhou[1], Wei Dou[1], Perry Grant[1], Joshua Grant[1], Sattar Al-Kabi[1], Wei Du[3], Greg Sun[4], Richard Soref[4], John Tolle[2], Baohua Li[5], Mansour Mortazavi[6], Shui-Qing Yu[1]; [1]*Univ. of Arkansas, USA;* [2]*ASM, USA;* [3]*Wilkes Univ., USA;* [4]*Univ. of Massachusetts Boston, USA;* [5]*Arktonics, LLC, USA;* [6]*Univ. of Arkansas at Pine Bluff, USA.* The GeSn photodetectors with Sn compositions up to 22.3% were systematically investigated. The maximum cutoff wavelength of 3.7 µm at 300 K and the peak specific detectivity of 9.5×10^{9} $cmHz^{1/2}W^{-1}$ at 77 K were achieved. Moreover, the infrared images were captured.

STh4O.7 • 18:15
Boron Alloys for GaAs-based 1.3µm Semiconductor Lasers, Rasha H. El-Jaroudi[1], Kyle M. McNicholas[1], Brent A. Bouslog[1], Iram E. Olivares[1], Rachel C. White[1], Joshua McArthur[1], Seth Bank[1]; [1]*Univ. of Texas at Austin, USA.* We present BGaInAs as a potential active region for 1.31µm laser sources on GaAs substrates. We demonstrate high quality BGaInAs films with high indium concentrations and multiple percent boron concentrations that emit at room temperature.

18:30–20:00 Emerging Trends in Nonlinear Optics - A Review of CLEO: 2019, *Room 230A*

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, *Location TBD*

07:30–12:00 Registration, *Concourse Level*

CLEO: QELS-Fundamental Science

Executive Ballroom 210A

08:00–10:00
FF1A • Single-Photon Detection
Presider: Joshua Bienfang; NIST Gaithersburg Maryland, USA

FF1A.1 • 08:00 Invited
Microwave Plasmonic Properties of Superconducting Thin Films May Enable Improved Single-Photon Detection, Karl Berggren[1]; *[1]MIT, USA.* Superconducting thin films have a strong microwave plasmonic characteristic which enables ultra-slow microwave propagation speeds and thus complex on-chip architectures for microwave circuits. We present a novel interferometric scheme for single-photon detection that would use a superconducting-nanowire-based microwave on-chip interferometer.

FF1A.2 • 08:30
Superconducting Nanowire Single Photon Detector with High Efficiency and Time Resolution for Multimode Fiber Coupling , Jin Chang[1], Iman E. Zadeh[1], Johannes W. Los[2], J Zichi[3], Val Zwiller[3]; *[1]Technology Univ. of Delft (TUD), Netherlands; [2]Single Quantum B.V., Netherlands; [3]Dept. of Applied Physics, Royal Inst. of Technology (KTH), Sweden.* In this paper, we report the development of a 50 µm diameter superconducting nanowire single photon detector with sub-19 ps timing jitter and saturated internal efficiency over a broad wavelength range for multimode fiber coupling.

FF1A.3 • 08:45
Exceeding 95% system efficiency within the telecom C-band in superconducting nanowire single photon detectors, Dileep V. Reddy[1,2], Robert R. Nerem[3], Adriana Lita[2], Sae Woo Nam[2], Richard P. Mirin[2], Varun B. Verma[2]; *[1]Univ. of Colorado Boulder, USA; [2]Applied Physics Division, National Inst. of Stantards and Technology, USA; [3]Montana State Univ.-Bozeman, USA.* We present a single-photon detector with system detection efficiencies exceeding 95% over the wavelength range 1520-1550 nm, with polarization sensitivities in the range of 1.02-1.08. The wavelength range is tunable over 200 nm via variation of the top-two dielectric layer thicknesses.

Executive Ballroom 210B

08:00–10:00
FF1B • Time Varying Metasurfaces
Presider: To Be Announced

FF1B.1 • 08:00 Invited
Linear Frequency Conversion in Time-Variant Metasurfaces, Bumki Min[1]; *[1]South Korea Advanced Inst of Science & Tech, South Korea (the Republic of).* The energy of an electromagnetic wave is converted as the wave passes through a temporal boundary. Here, we propose rapidly time-variant metasurfaces as a frequency converting platform and experimentally demonstrate their efficacy at THz frequencies.

FF1B.2 • 08:30
Time-modulated Metasurfaces for Dispersionless Wavefront Engineering of Light, Mohammad Mahdi Salary[1], Hossein Mosallaei[1]; *[1]Northeastern Univ., USA.* We introduce a dispersionless phase gradient for the light undergoing frequency conversion in a time-modulated metasurface and demonstrate its application for dynamic wavefront engineering of generated frequency harmonics in graphene-based and transparent conducting oxide metasurfaces.

FF1B.3 • 08:45
Frequency conversion through time refraction using an epsilon-near-zero material, Yiyu Zhou[1], Mohammad Karimi[2], Jeremy Upham[2], Orad Reshef[2], Cong Liu[3], Alan E. Willner[3], Zahirul Alam[2], Robert Boyd[1,2]; *[1]The Inst. of Optics, Univ. of Rochester, USA; [2]Dept. of Physics, Univ. of Ottawa, Canada; [3]Dept. of Electrical Engineering, Univ. of Southern California, USA.* We report a large and tunable frequency shifting over 14.8 THz bandwidth of an infrared probe beam through time refraction in indium tin oxide (ITO) in its epsilon-near-zero region. The sign of the frequency change can be controlled by adjusting the delay between a pump and the probe.

Executive Ballroom 210C

08:00–10:00
FF1C • Attosecond & High Field Sources
Presider: François Légaré; INRS, Canada

FF1C.1 • 08:00 Tutorial
Scaling of Strong-Field Physics into the Long Wavelength Limit, Louis F. DiMauro[1]; *[1]Physics, The Ohio State Univ., USA.* Studies of the wavelength scaling of an intense laser interacting with atoms and molecules is driving a renewed interest in the fundamental physics and a renaissance in potential applications in ultrafast imaging methods.

Louis F. DiMauro is Professor of Physics and Hagenlocker Chair at the Ohio State University. He is the recipient of the 2012 OSU Distinguish Scholar Award, the 2013 OSA Meggers Prize and the 2017 APS Schawlow Prize in Laser Science. He is a Fellow of the APS, OSA and AAAS.

Executive Ballroom 210D

08:00–10:00
FF1D • Solitons in Microresonators
Presider: To Be Announced

FF1D.1 • 08:00
Dual Comb Generation in a Symmetrically Driven Crystalline Microresonator, Romain Bouchand[1], Wenle Weng[1], Erwan Lucas[1], Tobias J. Kippenberg[1]; *[1]Ecole Polytechnique Fédérale de Lausanne, Switzerland.* We develop a dual-comb system based on a single crystalline microresonator by monochromatically pumping counter-propagating solitons in the same spatial mode with equal powers and unveil the role of soliton Cherenkov radiations interference in the process.

FF1D.2 • 08:15
Heteronuclear Soliton Molecules in Optical Microresonators, Wenle Weng[1], Romain Bouchand[1], Erwan Lucas[1], Ewelina Obrzud[2,3], Tobias Herr[2], Tobias J. Kippenberg[1]; *[1]Ecole Polytechnique Federale de Lausanne, Switzerland; [2]Swiss Center for Electronics and Microtechnology (CSEM), Switzerland; [3]Univ. of Geneva, Switzerland.* We enter the multi-stability regime of an optical microresonator to generate het- eronuclear soliton molecules. Ultrafast electro-optical sampling reveals the bound structures of such soliton molecules, despite comprising solitons of dissimilar amplitudes, durations and frequencies.

FF1D.3 • 08:30
Measuring the Optical Temperature of a Soliton, Pawel Jung[1,2], Fan Wu[1], Absar U. Hassan[1], Demetrios N. Christodoulides[1]; *[1]The College of Optics and Photonics, Univ. of Central Florida, USA; [2]Faculty of Physics, Warsaw Univ. of Technology, Poland.* Under thermal equilibrium conditions, we show that the zeroth law of thermodynamics can be used to measure a soliton's optical temperature in a nonlinear multimode system. Here, the modal gas plays the role of an optical thermometer.

FF1D.4 • 08:45
Soliton Elasticity, Oliver Melchert[1,2], Stephanie Willms[1], Ihar Babushkin[1], Bernhard Roth[2], Günter Steinmeyer[3,4], Uwe Morgner[1], Ayhan Demircan[1,2]; *[1]Leibniz Univ. Hannover, Germany; [2]Hannover Centre for Optical Technologies, Germany; [3]Max-Born-Inst., Germany; [4]Humboldt Univ. Berlin, Germany.* We extend the analogy of particle-like behavior of solitons one decisive step further, demonstrating completely Newtonian collisions for unequal solitons, detached from any wave properties. They even act like extended massive objects, exhibiting elastic deformation.

07:30–12:00 **Registration,** *Concourse Level*

Executive Ballroom 210E

CLEO: Science & Innovations

08:00–10:00
SF1E • Ultrafast Applications
Presider: Alan Fry; SLAC, USA

SF1E.1 • 08:00 Invited
Laser-based 3D Printing for Biomedical Applications, Maria Farsari[1]; *[1]IESL-FORTH, Greece.* We present our most recent results into the 3D laser printing of scaffolds and biomedical implants using a series of novel functional materials.

SF1E.2 • 08:30 Invited
High Performance Nanoscale Imaging with Table-Top XUV Sources, Jan Rothhardt[1,2], Wilhelm Eschen[1,2], Getnet Tadesse[1,2], Robert Klas[1,2], Jens Limpert[1,2]; *[1]Helmholtz Inst. Jena, Germany; [2]Inst. of Applied Physics, Friedrich-Schiller-Univ., Germany.* This talk will present the latest achievements in high performance coherent diffractive imaging at the nanoscale enabled by fiber-laser based high photon flux table-top high harmonic sources.

Executive Ballroom 210F

CLEO: QELS-Fundamental Science

08:00–10:00
FF1F • Machine Learning & Quantum Exotica
Presider: Peter Mosley; University of Bath, UK

FF1F.1 • 08:00
Entanglement-Enhanced Physical-Layer Classifier Using Supervised Machine Learning, Quntao Zhuang[1,2], Zheshen Zhang[3,4]; *[1]Dept. of Physics, Univ. of California, Berkeley, USA; [2]Dept. of Electrical and Computer Engineering, Univ. of Arizona, USA; [3]Dept. of Materials Science and Engineering, Univ. of Arizona, USA; [4]College of Optical Sciences, Univ. of Arizona, USA.* We introduce physical-layer classifiers enhanced by multipartite entanglement learned through a supervised support-vector machine. The required entangled states are practical and give error probability advantage over classical schemes even in presence of loss.

FF1F.2 • 08:15
Quantum Photonic Neural Networks, Gregory Steinbrecher[1], Jonathan Olson[2], Dirk R. Englund[1], Jacques Carolan[1]; *[1]MIT, USA; [2]Zapata Computing Inc., USA.* We propose an architecture for next generation quantum photonic processors, which maps the features of neural networks into the quantum optical domain. Through numerical simulation we demonstrate a range of new quantum information processing tasks.

FF1F.3 • 08:30
Bayesian machine learning of frequency-bin CNOT, Hsuan-Hao Lu[2], Joseph M. Lukens[1], Brian P. Williams[1], Poolad Imany[2], Nicholas A. Peters[1], Andrew M. Weiner[2], Pavel Lougovski[1]; *[1]Quantum Information Science Group, Oak Ridge National Lab, USA; [2]School of Electrical and Computer Engineering, Purdue Univ., USA.* We analyze the first experimental two-photon frequency-bin gate: a coincidence-basis CNOT. A novel characterization approach based on Bayesian machine learning is developed to estimate the gate performance with measurements in the logical basis alone.

Executive Ballroom 210G

CLEO: Science & Innovations

08:00–10:00
SF1G • Devices for Communications
Presider: Francesco Da Ros; Technical University of Denmark, Denmark

SF1G.1 • 08:00 Invited
Programmable Integrated Photonics: Is it the right time for Field Programmable Arrays?, Jose Capmany[1], Daniel Perez[1], Ivana Gasulla[1], Prometheus Das Mahapatra[1]; *[1]Universidad Politecnica de Valencia, Spain.* Programmable photonics is an emerging paradigm based on using a common integrated optical hardware architecture to implement multiple functions by software programming. Field Programmable Photonic Arrays enable its implementation, but is the technology ready?

SF1G.2 • 08:30
Bit error rate performance of bias-free operational UTC-PD for high baud rate communications up to 100 Gbaud, Toshimasa Umezawa[1], Atsushi Matsumoto[1], Atsushi Kanno[1], Naokatsu Yamamoto[1], Tetsuya Kawanishi[2,1]; *[1]National Inst of Information & Comm Tech, Japan; [2]Waseda Univ., Japan.* We fabricated a bias free operational high bandwidth photodetector operated over 110-GHz, and characterized the bit error performance at up to 100-Gbaud. At 90-Gbaud, BER<1×10^{-3} was confirmed without a frequency equalizer or a DSP.

Executive Ballroom 210H

08:00–10:00
SF1H • Phase-matching Techniques
Presider: Sergey Vasilyev; IPG Photonics, USA

SF1H.1 • 08:00
A 2.35-µm pumped subharmonic OPO reaches the spectral width of two octaves in the mid-IR, Qitian Ru[1], Peter G. Schunemann[2], Sergey Vasilyev[3], Sergey Mirov[3,4], Konstantin L. Vodopyanov[1]; *[1]CREOL, College of Optica and Photonics, Univ. of Central Florida, USA; [2]BAE Systems, USA; [3]IPG Photonics - Mid-infrared Lasers, USA; [4]Dept. of Physics, Univ. of Alabama at Birmingham, USA.* We used an orientation-patterned gallium phosphide (OP-GaP) crystal combined with an ultrafast 2.35-µm pump (1.2W, 79 MHz, 62 fs) to demonstrate a subharmonic sync-pumped OPO with an instantaneous output spectrum of 3–12.5 µm.

SF1H.2 • 08:15
Generation of wavelength- and mode-controllable Poincaré sphere beams from a femtosecond optical parametric oscillator, Jintao Fan[1], Na Xiao[1], Jun Zhao[1], Haosen Shi[1], Ruoyu Liao[1], Chen Xie[1], Youjian Song[1], Minglie Hu[1]; *[1]Tianjin Univ., China.* We report on a femtosecond optical parametric oscillator which is capable of generating on-demand arbitrary higher-order Poincaré (HOP) sphere beams tunable from 1376 to 1626 nm.

SF1H.3 • 08:30
Single-Frequency Operation of a Near-degenerate Optical Parametric Oscillator Using a Transversally Chirped Volume Bragg Grating, Adeline Kabacinski[1], Julie Armougom[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Jean-Baptiste Dherbecourt[1], Antoine Godard[1], Ruslan Vasilyeu[2], Vadim Smirnov[2]; *[1]ONERA, France; [2]Optigrate (IPG), USA.* We report on a doubly-resonant optical parametric oscillator emitting single-frequency radiation near 2 µm using Vernier spectral filtering and a Bragg reflector. The wavelength is tuned over 22 nm using a chirped Bragg grating period.

SF1H.4 • 08:45
Coherent Temporal Phase Transfer in Backward Wave Parametric Oscillator at 1.4 µm, Anne-Lise Viotti[1], Fredrik Laurell[1], Andrius Zukauskas[1], Carlota Canalias[1], Valdas Pasiskevicius[1]; *[1]Royal Inst. of Technology, Sweden.* The frequency modulation transfer property of a backward wave optical parametric oscillator is employed to generate compressed near-IR pulses at 1.4µm with 1.3ps duration. Limitations to the linear frequency modulation transfer in BWOPO are investigated.

07:30–12:00 Registration, *Concourse Level*

Meeting Room 211 A/B

CLEO: Science & Innovations

08:00–10:00
SF1I • Frequency-Comb-Based Sensing
Presider: Aleksandra Foltynowicz Umea University, Sweden

SF1I.1 • 08:00
Mid-infrared Dual-comb Spectroscopy of Volatile Organic Compounds Across Long Open-air Paths, Fabrizio R. Giorgetta[1,2], Gabriel Ycas[1,2], Kevin C. Cossel[1], Eleanor Waxman[1], Esther Baumann[1,2], Nathan R. Newbury[1], Ian Coddington[1]; *[1]NIST, USA; [2]Physics, Univ. of Colorado, USA.* Volatile organic compounds are probed across up to 1 km-long open-air paths with mid-infrared dual-comb spectroscopy. Quantitative concentrations of released acetone and isopropanol and atmospheric ethane are measured with ppm-m-level sensitivities.

SF1I.2 • 08:30
Background-Free Mid-Infrared Absorption Spectroscopy Based on Interferometric Suppression with a Sign-Inverted Waveform, Teemu Tomberg[2], Andrey Muraviev[1], Qitian Ru[1], Konstantin L. Vodopyanov[1]; *[1]Univ. of Central Florida, CREOL, USA; [2]Dept. of Chemistry, Univ. of Helsinki, Finland.* Using a broadband dual-comb system, we implement a new type of background-free spectroscopy based on a Michelson interferometer operating in a dark fringe. This strongly improves detection sensitivity and reduces requirements for detector dynamic range.

SF1I.3 • 08:45
Automatic Interpolation of 25 GHz Mode Spacing in Dual EOM Comb Spectroscopy, Tadashi Nishikawa[1], Akira Oohara[1], Shohei Uda[1], Atsushi Ishizawa[2], Kenichi Hitachi[2], Nathalie Picqué[3,4], Theodor W. Hänsch[3,4]; *[1]Tokyo Denki Univ., Japan; [2]NTT Basic Research Labs, Japan; [3]Max-Planck-Institut für Quantenoptik, Germany; [4]Ludwig-Maximilians-Universität München, Germany.* Automatic interpolation of 25GHz mode spacing in dual EOM comb spectroscopy has been demonstrated. By single shot measurement of 9.3ms, $H^{13}C^{14}N$ absorption spectrum spanning more than 0.8THz with 100MHz resolution could be obtained.

Meeting Room 211 C/D

08:00–10:00
SF1J • Plasmonics, Optomechanics, & Metamaterials
Presider: Karen Grutter, Univ. of Maryland at College Park, USA

SF1J.1 • 08:00 Invited
A Few Novel Effects in Plasmonics, Marin Soljacic[1]; *[1]MIT, USA.* Some of our recent work in plasmonics will be presented, including novel free-electron light sources, as well as structures for enhanced light emission, and tailoring light-flow.

SF1J.2 • 08:30
Record Purcell Factor in Hybrid Plasmonic Waveguides, Yiwen Su[1], Pohan Chang[1], Charles Lin[1], Amr S. Helmy[1]; *[1]Univ. of Toronto, Canada.* A composite hybrid plasmonic waveguide is demonstrated to exhibit long-range propagation (0.03dB/μm) and subwavelength confinement simultaneously while unrestricted from structural or modal symmetry coupling conditions. Purcell factors of 1.5x10^4 were measured in traveling-wave ring-resonators.

SF1J.3 • 08:45
Hexagonal boron nitride cavity optomechanics, Prasoon Kumar Shandilya[1], Johannes E. Froch[2], Matthew Mitchell[1], David Lake[1], Sejeong Kim[2], Milos Toth[2], Bishnupada Behera[1], Chris Healey[1], Igor Aharonovich[2], Paul E. Barclay[1]; *[1]Inst. for Quantum Science and Technology, Univ. of Calgary, Canada; [2]Inst. of Biomedical Materials and Devices, Univ. of Technology Sydney, Australia.* Hexagonal boron nitride (hBN) is an emerging layered material that plays a key role in a variety of 2D devices. Here, we demonstrate the first hBN cavity optomechanical system by integrating hBN nanobeams with silicon microdisk cavities. The system has 0.29pm/√Hz sensitivity to hBN nanobeam motion.

Meeting Room 212 A/B

CLEO: Applications & Technology

08:00–10:00
AF1K • Structural Monitoring
Presider: Gregory Rieker; University of Colorado at Boulder, USA

AF1K.1 • 08:00
VCSEL Based FBG Sensor Network Interrogator for Lightning Strike Testing of Airframes, Guodong Guo[1], Brandon Hearley[1], Mark Pankow[1], Kara Peters[1]; *[1]North Carolina State Univ., USA.* We develop a low-power, VCSEL based FBG sensor network interrogator for high-speed measurements of thermal and mechanical induced strains in composite airframes during lightning strikes.

AF1K.2 • 08:30
Sub-nε Static Resolution Fiber Laser Sensor, Shuangxiang Zhao[1], Qingwen Liu[1], Jiageng Chen[1], Zuyuan He[1]; *[1]Shanghai Jiao Tong Univ., China.* A fiber laser sensor system capable of both static and dynamic strain measurement is presented. Using Pound-Drever-Hall and injection-locking techniques, resolution of 276 pε in 1000 s and 450 fε at l kHz is demonstrated.

AF1K.3 • 08:45
Strain Sensitivity Enhancement by Polarization-Maintaining Fiber Bragg Gratings, Dipenkumar Barot[1], Lingze Duan[1]; *[1]Univ. of Alabama in Huntsville, USA.* A novel and simple approach for dynamic strain measurement is demonstrated. By using polarization-maintaining fiber Bragg grating and balanced detection, both strain sensitivity and signal-to-noise ratio are enhanced by over an order of magnitude.

Meeting Room 212 C/D

CLEO: Science & Innovations

08:00–10:00
SF1L • Fiber Parametric Sources
Presider: Sze Y. Set The University of Tokyo, Japan

SF1L.1 • 08:00
Femtosecond Optical Parametric Oscillator Based on Vector Four-Wave-Mixing in Step-Index Fiber, Walter P. Fu[1], Frank W. Wise[1]; *[1]Cornell Univ., USA.* We present a fiber optical parametric oscillator based on polarization-maintaining, step-index fiber. Using birefringence-induced phase-matching, we convert chirped pulses at 1 μm to nanojoule-scale, femtosecond pulses at 0.8 μm and 1.3 μm.

SF1L.2 • 08:15
Rapidly and Widely Tunable All-Fiber Optical Parametric Oscillator, Maximilian Brinkmann[1,2], Tim Hellwig[1,2], Carsten Fallnich[1,2]; *[1]Inst. of Applied Physics, Univ. of Münster, Germany; [2]Refined Laser Systems, Univ. of Münster, Germany.* We present high-speed tuning in 5 ms per arbitrary wavelength step from 750 to 970 nm of a robust all-fiber optical parametric oscillator without the need for a mechanical delay.

SF1L.3 • 08:30
Stretched-Pulse Solitons in Driven Fiber Resonators, Qian Yang[1], Christopher Spiess[1], Victor G. Bucklew[1], William H. Renninger[1]; *[1]Univ. of Rochester, USA.* Stable broadband solitons are observed in a driven nonlinear resonator consisting of fibers with opposite signs of dispersion. Corresponding numerical simulations reveal periodic temporal stretching of the pulse, characteristic of stretched-pulse solitons in mode-locked lasers.

SF1L.4 • 08:45
Highly-Chirped Solitons in Driven Resonators, Christopher Spiess[1], Qian Yang[1], Victor G. Bucklew[1], William H. Renninger[1]; *[1]Univ. of Rochester, USA.* Here we investigate driven fiber resonators with large net normal dispersion and a narrowband intracavity spectral filter. A range of stable solutions are observed, including the first experimental and numerical observations of highly-chirped solitons.

07:30–12:00 Registration, *Concourse Level*

CLEO: Science & Innovations

Marriott Salon I & II

08:00–10:00
SF1M • Fiber-Based Information Process
Presider: Kazi Abedin, OFS Laboratories, USA

SF1M.1 • 08:00 Invited
Device independent quantum information processing---- from Bell inequality to fiber QKD, Qiang Zhang[1]; *[1]Univ of Science and Technology of China, China.* Bell expeirment provides not only a way to test quantum nonlocality but also to implement quantum informaiton independent of any device. Here, I shall introduce the recent experimental progress in loophole free Bell test and device independent quantum random number generation.

SF1M.2 • 08:30
Solving large-scale NP-Complete problem with an optical solver driven by a dual-comb 'clock', Yalin Hou[1], Xin Zhao[1], Qian Li[1], Jie Chen[1], Yihong Li[1], Zheng Zheng[1,2]; *[1]School of Electronic and Information Engineering, Beihang Univ., China; [2]Beijing Advanced Innovation Center for Big Date-based Precision Medicine, China.* A scheme using a simple dual-comb fiber laser to solve large instance NP-C problems is demonstrated based on asynchronous sampling measurement of pulse delays through a fiber network, subpicosecond resolution and nanosecond range are achieved.

SF1M.3 • 08:45
All-optical Ultrafast Switching Based on Plasmon-generated Hot Carriers in Gold-coated Fiber Gratings, Fu Liu[1]; *[1]Dept. of Electronics, Carleton Univ., Canada.* Pump-probe modulation of 4.95% is observed experimentally and by simulations in gold-coated tilted fiber Bragg gratings at power densities of 205 MW/cm^2 with 25 ps pulses from a tunable laser at wavelengths near 1550 nm.

Marriott Salon III

08:00–10:00
SF1N • AI for Integrated Photonics
Presider: Alan Wang; Oregon State Univ., USA

SF1N.1 • 08:00
Integrated Nanophotonic Ising Sampler, Mihika Prabhu[1], Charles Roques-Carmes[1], Yichen Shen[3], Nicholas C. Harris[2], Li Jing[1], Jacques Carolan[1], Ryan Hamerly[1], Tom Baehr-Jones[4], Michael Hochberg[4], Vladimir Ceperic[1], John D. Joannopoulos[1], Dirk R. Englund[1], Marin Soljacic[1]; *[1]MIT, USA; [2]Lightmatter, USA; [3]Lightelligence, USA; [4]Elenion Technologies, USA.* We demonstrate an integrated silicon photonic Markov Chain Monte Carlo sampler capable of high-probability convergence to the ground state of various 4-spin Ising graphs. Robustness to getting trapped in local minima is enhanced by experimental system noise.

SF1N.2 • 08:15
Deep Learning-designed Diffractive Neural Networks, Xing Lin[1], Yair Rivenson[1], Nezih Yardimci[1], Muhammed Veli[1], Yi Luo[1], Mona Jarrahi[1], Aydogan Ozcan[1]; *[1]Univ. of California Los Angeles, USA.* We report deep learning-based design of diffractive neural networks. Following its fabrication, a diffractive neural network can all-optically perform user-defined tasks through diffraction. We demonstrate the applications of this framework for classification and imaging tasks.

SF1N.3 • 08:30 Invited
Programmable Nanophotonics for Machine Learning Acceleration, Nicholas C. Harris[1], Darius Bunandar[1], Carl Ramey[1]; *[1]Lightmatter, Inc., USA.* Recent work has shown compatibility of neural networks with mixed- and low-precision number representations, prompting exploration into analog compute platforms. Here, we will discuss the application of silicon photonics, typically viewed as a communications platform, to the problem of deep learning.

Marriott Salon IV

08:00–10:00
SF1O • Perovskites
Presider: Jiming Bao; Univ. of Houston, USA

SF1O.1 • 08:00 Invited
Efficient, Color Tunable, and Flexible Thin Film Perovskite Light Emitting Devices, Barry P. Rand[1]; *[1]Princeton Univ., USA.* We present a general protocol to prepare light emitting diodes based upon metal halide perovskites exceeding 17% external quantum efficiency, with improved stability, and which are as flexible as organic electronic thin films. Finally, we show stabilized mixed halide (I and Br) and mixed Pb-Sn stoichiometries such that we can tune emission from the green to near infrared.

SF1O.2 • 08:30
High-performance X-ray Detector Based on Solution-synthesized Thin-film Perovskite, Xiangming Liu[1], Zhigang Zang[2], Ming Wang[2], Tao Xu[1], Yulong Li[1], Xiaoshi Peng[1], Huiyue Wei[1], Zanyang Guan[1], Yonggang Liu[1], Feng Wang[1]; *[1]Laser Fusion Research Center, CAEP, China; [2]Key Lab of Optoelectronic Technology & Systems, Chongqing Univ., China.* We present a high-performance X-ray detector based on a solution-synthesized perovskite film. The sensitivity as high as 30 μC Gy^{-1}cm^{-2} is realized. More importantly, the as-prepared detectors exhibit a fast photoresponse with a high stability.

SF1O.3 • 08:45
Visualizing the Creation and Healing of Traps in Perovskite Photovoltaic Films by Light Soaking and Passivation treatments, Andrew Winchester[1], Stuart Macpherson[2], Vivek Pareek[1], Mojtaba Abdi-Jalebi[2], Zahra Andaji-Garmaroudi[2], Christopher Petoukhoff[1], E Laine Wong[1], Julien Madéo[1], Michael K. Man[1], Samuel Stranks[2], Keshav M. Dani[1]; *[1]Femtosecond Spectrocopy Unit, Okinawa Inst. of Science and Technology, Japan; [2]Cavendish Lab, Univ. of Cambridge, UK.* Eliminating carrier traps in hybrid organic-inorganic perovskites is crucial for their application. We study the effects of passivation and light soaking treatments on changing surface traps in perovskite films using photoemission electron microscopy.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FF1A • Single-Photon Detection—Continued

FF1A.4 • 09:00
High Efficiency Planar Ge-on-Si Single-Photon Avalanche Diode Detectors, Jaroslaw Kirdoda[1], Lourdes Ferre Llin[1], Kateryna Kuzmenko[2], Peter Vines[2], Zoe M. Greener[2], Derek C. Dumas[1], Ross Millar[1], Muhammad M. Mirza[1], Gerald S. Buller[2], Douglas J. Paul[1]; [1]*Univ. of Glasgow, UK;* [2]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK.* Planar Ge-on-Si single-photon avalanche diode detectors fabricated using CMOS-compatible processing demonstrate a 38% single photon detection efficiency at 125 K with 1310 nm wavelength illumination, exhibiting 310 ps jitter and 2×10^{-16} $WHz^{-1/2}$ noise equivalent power.

FF1A.5 • 09:15
Single Photon Detectors's Timing-Jitter Quantum Description, Élie Gouzien[1], Bruno Fedrici[1], Alessandro Zavatta[2,3], Sébastien Tanzilli[1], Virginia D'Auria[1]; [1]*Institut de Physique de Nice, Université Côte d'Azur, France;* [2]*Istituto Nazionale di Ottica, Italy;* [3]*LENS and Dept. of Physics, Universitá di Firenze, Italy.* We model single photon detectors by explicitly taking into account their timing-jitter, finite efficiency and dead-time effects. Our model represents the first operational and full description of temporal limitations of those detectors.

FF1A.6 • 09:30
Quantum tomography of a single-photon state by photon-number parity measurements, Rajveer Nehra[1], Aye Win[1], Miller Eaton[1], Niranjan Sridhar[1,2], Reihaneh Shahrokhshahi[1,3], Thomas Gerrits[4], Adriana Lita[4], Sae Woo Nam[4], Olivier Pfister[1]; [1]*Univ. of Virginia, USA;* [2]*Google, Inc., USA;* [3]*Xanadu, Canada;* [4]*National Inst. of Standards and Technology,, USA.* A single-photon state was generated by heralding cavity-enhanced spontaneous parametric downconversion in a PPKTP optical parametric oscillator. The Wigner distribution was reconstructed by quantum state tomography, using photon-number-resolving measurements with a system efficiency of 58 +-2%.

FF1A.7 • 09:45
Quantum illumination with x-rays, Sason Sofer[1,2], Edward Strizhevsky[1,2], Aviad Schori[1,2], Kenji Tamasaku[2], Sharon Shwartz1[1,2]; [1]*Physics Dept. and Inst. of Nan, Israel;* [2]*RIKEN SPring-8 Center, Japan.* We present the experimental realization of quantum illumination with x-rays. By using entangled photons, we detected the presence of an object in a noisy environment and improved the visibility substantially compared to classical methods.

10:00–10:30 Coffee Break, *Concourse Level*

FF1B • Time Varying Metasurfaces—Continued

FF1B.4 • 09:00
Time-varying Huygens' Metadevices for Parametric Wave Controls, Mingkai Liu[1], David Powell[2,1], Yair Zarate[1], Ilya Shadrivov[1]; [1]*Australian National Univ., Australia;* [2]*Univ. of New South Wales, Australia.* Dynamic and arbitrary control of electromagnetic waves is challenging. We introduce time-varying Huygens' metadevices for efficient parametric conversion and demonstrate experimentally that the amplitude, phase, and scattering of parametric waves can be manipulated almost arbitrarily.

FF1B.5 • 09:15
Broadband Switches Using Photonic Aharonov-Bohm Interferometers and Dynamic Modulation, Ian Williamson[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We introduce an optical switch using an Aharonov-Bohm interferometer constructed from gauge potentials in dynamically modulated waveguides. Our results show that such a switch can have a far broader bandwidth than the conventional Mach-Zehnder interferometer.

FF1B.6 • 09:30
Dynamic Phase Modulation Induced Nonreciprocity of Optical Metasurfaces, Xuexue Guo[1], Yimin Ding[1], Yao Duan[1], Xingjie Ni[1]; [1]*Pennsylvania State Univ., USA.* By exploiting both spatial and temporal phase modulation, we experimentally demonstrate an ultrathin nonlinear metasurface with broken reciprocity at wavelengths around 860 nm. Our approach paves a way for miniaturized on-chip nonreciprocal optical components.

FF1B.7 • 09:45
Noninteracting Multilayer Dielectric Metasurfaces for Multiwavelength Metaoptics, You Zhou[1], Ivan Kravchenko[2], Hao Wang[3], Joshua R. Nolen[1], Gong Gu[3], Jason Valentine[1]; [1]*Vanderbilt Univ., USA;* [2]*Oak Ridge National Lab, USA;* [3]*Univ. of Tennessee, USA.* We report a multilayer dielectric metasurface platform that increases the design flexibility of metasurfaces. We numerically and experimentally demonstrate multiwavelength metaoptics using this platform.

FF1C • Attosecond & High Field Sources—Continued

FF1C.2 • 09:00
Low-Order Harmonic Generation in Mid-Infrared Laser Filaments in Gases, Claudia Gollner[2], Valentina Shumakova[2], Audrius Pugzlys[2], Andrius Baltuska[2], Pavel G. Polynkin[1]; [1]*Univ. of Arizona, USA;* [2]*Technical Univ. of Vienna, Austria.* We detect up to 11[th]-order harmonics generated through filamentation of ultrashort laser pulses at 3.9um wavelength in air and argon. Harmonic's spectra map the nonlinear evolution of the mid-infrared driver and exhibit CEP-dependent spectral interference.

FF1C.3 • 09:15
Measuring a Few-pulse Attotrain from CEP-dependent Relativistic High Harmonics, Guangjin Ma[1,2], Dmitrii Kormin[3,4], Antonin Borot[3], William Dallari[3], Boris Bergues[3,4], Mark Aladi[5], Istvan Foldes[5], Jin He[1], Laszlo Veisz[3,6]; [1]*Shenzhen SoC Key Lab, Peking Univ. Shenzhen Inst. & PKU-HKUST Shenzhen-Hong Kong Institution, China;* [2]*Center for Free-Electron Laser Science, DESY, Germany;* [3]*Max-Planck-Institut für Quantenoptik, Germany;* [4]*Ludwig-Maximilian-Universität München, Germany;* [5]*Wigner Research Centre for Physics, Hungarian Academy of Sciences, Hungary;* [6]*Dept. of Physics, Umea Univ., Sweden.* We present laser-waveform-dependent relativistic high harmonics from plasma surfaces, and use spectral interferometry to understand its generation process. The attotrain structure as well as the field-driven plasma surface motion during the process are revealed.

FF1C.4 • 09:30
First experimental steps toward an *in situ* gauge for direct measurement of relativistic intensities, Wendell T. Hill[1], Calvin He[1], Luis Roso[2], José A. Pérez-Hernández[2], Giancarlo Gatti[2], Massimo de Marco[2], Robert Fedosejevs[3], Andrew Longman[3]; [1]*Univ. of Maryland at College Park, USA;* [2]*Centro de Láseres Pulsados, Spain;* [3]*Univ. of Alberta, Canada.* Nearly 50 years ago Sarachik and Schappert suggested an intensity gauge based on wavelength shifts due to relativistic Thomson scattering. We present the first preliminary experimental results exploiting these shifts to make a direct measurement of peak intensities above 10^{18} W/cm^2.

FF1C.5 • 09:45
Demonstration of Tunable Relativistic, Single-Cycle Infrared Pulses from a Tailored Plasma Structure, Zan Nie[1], Chih-Hao Pai[1], Jie Zhang[1], Xiaonan Ning[1], Jianfei Hua[1], Chaojie Zhang[2], Yunxiao He[1], Yipeng Wu[1], Qianqian Su[1], Shuang Liu[1], Yue Ma[1], Zhi Cheng[1], Wei Lu[1], Hsu-Hsin Chu[3], Jyhpyng Wang[3,4], Warren B. Mori[2], Chan Joshi[2]; [1]*Tsinghua Univ., China;* [2]*Univ. of California Los Angeles, USA;* [3]*National Central Univ., Taiwan;* [4]*National Taiwan Univ., Taiwan.* We demonstrate that relativistic, single-cycle infrared pulses tunable in the spectral range of 3-19 µm can be generated from a tailored plasma structure using an 810 nm drive laser.

FF1D • Solitons in Microresonators—Continued

FF1D.5 • 09:00
Perfect soliton crystals in optical microresonators, Maxim Karpov[1], Martin Pfeiffer[1], Hairun Guo[1], Junqiu Liu[1], Wenle Weng[1], Tobias J. Kippenberg[1]; [1]*Lab. of Photonics and Quantum Measuremen, Switzerland.* We demonstrate the existence of perfect soliton crystal states and develop the deterministic procedure for their excitation in Si_3N_4 microresonators. We show that despite exceptional symmetrical properties, their behavior is strongly linked to the chaotic regimes of the microresonator.

FF1D.6 • 09:30
Kerr-breather-soliton time crystals, Scott Papp[1], Daniel C. Cole[1]; [1]*NIST, USA.* We describe Kerr-breather-soliton time crystals in which a breathing excitation is sub-harmonically locked to the repetition frequency. Nonlinear modeling explores the behavior of soliton time crystals, and we will report on progress towards their observation.

FF1D.7 • 09:45
Gaussian Pulses in Kerr Nonlinear Microresonators with Pure Quartic Modal Dispersion, Hossein Taheri[1], Andrey B. Matsko[2], Anatoliy Savchenkov[2]; [1]*ECE, Univ. of California, Riverside, USA;* [2]*OEwaves Inc., USA.* Gaussian pulses in Kerr-nonlinear microresonators with pure quartic modal dispersion are reported. Using a variational approach, pulse parameters are found in terms of experimentally tunable quantities and verified through numerical simulations and comparison with experiment.

Executive Ballroom 210E

CLEO: Science & Innovations

SF1E • Ultrafast Applications—Continued

SF1E.3 • 09:00
Ultrafast Infrared Vibrational Nanoscopy: Imaging Structure, Coupling and Dynamics on the Molecular Scale, Jun Nishida[1], Sven A. Dönges[1], Omar Khatib[1], Markus B. Raschke[1]; [1]*Univ. of Colorado Boulder, USA.* We demonstrate spatio-temporal-spectral nano-imaging through vibrational heterodyne pump-probe infrared scattering scanning near-field optical miscroscopy (HPP IR s-SNOM), revealing the coupled electronic and molecular structural dynamics in a triple cation perovskite film.

SF1E.4 • 09:15
Hyperspectral Microscopy with Broadband Infrared Frequency Combs, Henry Timmers[1], Abijith Kowligy[1], Alexander Lind[1], Nima Nader[1], Jonah Shaw[1], Dobryna Zalvidea[2], Jens Biegert[3], Scott A. Diddams[1]; [1]*NIST, USA;* [2]*Inst. of Bioengineering of Catalonia, Spain;* [3]*ICFO, Spain.* We present a new modality for infrared, hyperspectral microscopy using dual-comb, electro-optic sampling of octave-spanning infrared frequency combs. We obtain hyperspectral images of SU8 test patterns on Si wafers with a spatial resolution of 12 μm.

SF1E.5 • 09:30
Laser Interference Processing of Electron Phase Holograms by Using a Femtosecond Laser, Yuuki Uesugi[1], Ryota Fukushima[1], Shunichi Sato[1], Koh Saitoh[2]; [1]*Tohoku Univ., Japan;* [2]*Nagoya Univ., Japan.* Electron phase hologram was fabricated by a single-shot femtosecond laser interference processing. The generation of electron vortices from the fabricated hologram was demonstrated with higher diffraction efficiency than that of amplitude hologram as expected.

SF1E.6 • 09:45
Spatio-temporal Measurement of Ionization-induced Modal Index Evolution in Gas-filled Hollow-core Photonic Crystal Fiber, Mallika I. Suresh[1], Barbara M. Trabold[1], Johannes R. Koehler[1], Michael H. Frosz[1], Francesco Tani[1], Philip S. Russell[1]; [1]*Max Planck Inst. for the Science of Light, Germany.* Using a prism side-coupling technique, we selectively excite four different higher order guided modes in a gas-filled single-ring hollow core photonic crystal fiber and use them to probe transverse photoionization-induced refractive index changes.

Executive Ballroom 210F

CLEO: QELS-Fundamental Science

FF1F • Machine Learning & Quantum Exotica—Continued

FF1F.4 • 09:00
Indistinguishable Photon Source in the 1550-nm Band Optimized by Machine Learning, Chaohan Cui[1], Yi Xia[1], Saikat Guha[1], Nasser Peyghambarian[1], Zheshen Zhang[2,1]; [1]*College of Optical Sciences, The Univ. of Arizona, USA;* [2]*Dept. of Materials Science and Engineering, The Univ. of Arizona, USA.* We report a recipe for optimized poling design to generate spectrally-pure photons around 1550 nm. Our approach hinges on machine-learning techniques without requiring group-velocity matching.

FF1F.5 • 09:15
Non-Abelian Geometric Phases in Photonics and their Optimal Design Strategy Based on Quantum Metric, Mark Kremer[1], Lucas Teuber[1], Alexander Szameit[1], Stefan Scheel[1]; [1]*Inst. of Physics, Univ. of Rostock, Germany.* We experimentally realize non-Abelian geometric phases in photonic structures, hence using an Abelian-gauge field. The process is optimized by the novel concept of utilizing the quantum metric, ensuring the adiabicity of the underlying process.

FF1F.6 • 09:30
Free Electron Qubits, Ori Reinhardt[1], Chen Mechel[1], Morgan Lynch[1], Ido Kaminer[1]; [1]*Technion, Israel.* We show that a single relativistic free electron can carry one or multiple qubits within its wave-function in Floquet-dressed basis and implement 1-qubit gates based on the electron interaction with designed optical pulses.

FF1F.7 • 09:45
Covert sensing using floodlight illumination, Christos Gagatsos[1], Boulat A. Bash[1], Animesh Datta[2], Zheshen Zhang[1], Saikat Guha[1]; [1]*Univ. of Arizona, USA;* [2]*Univ. of Warwick, UK.* We present an active covert phase sensing scheme using floodlight illumination from an amplified spontaneous emission (ASE) source. We show that the performance of an ASE source is substantially superior compared to a laser source.

Executive Ballroom 210G

Executive Ballroom 210H

CLEO: Science & Innovations

SF1G • Devices for Communications—Continued

SF1G.3 • 09:00 Invited
Coherent Optical Communications with Microresonator Frequency Combs, Victor Torres Company[1]; [1]*Chalmers Tekniska Hogskola, Sweden.* In this talk I will describe recent system-level communication experiments based on wavelength division multiplexing using advanced modulation formats and microresonator frequency combs as multi-carrier light sources.

SF1G.4 • 09:30
Theoretical investigation of a Si RRM assisted SSB-OFDM modulator operated with a semiconductor MLL, Jovana Nojic[1], Saeed Sharif Azadeh[1], Juliana Müller[1], Xu Sun[2], Florian Merget[1], Jeremy Witzens[1]; [1]*Inst. of Integrated Photonics, RWTH Aachen Univ., Germany;* [2]*Songshanhu Jiaweo Base, Huawei Technologies Co. Ltd, China.* Performance of a transmitter with RRM-assisted SSB-OFDM modulator and semiconductor MLL is modeled. Phase noise related penalties arise even in back-to-back configuration and significantly modify the optimum RRM bias point.

SF1H • Phase-matching Techniques—Continued

SF1H.5 • 09:00 Invited
Quasi-Phasematched Semiconductors for Nonlinear Optical Frequency Conversion, Peter G. Schunemann[1]; [1]*BAE Systems Inc, USA.* The orientation-patterned compound semiconductors - OP-GaAs and OP-GaP - exhibit the highest nonlinear coefficients and broadest infrared transparency ranges among all quasi-phasematched crystals. Processing and device performance are improving, and next-generation materials show great promise.

SF1H.6 • 09:30
Measurement of d-coefficients of $CdSiP_2$ using Non-phase-matched Second Harmonic Generation of 2700 to 4700 nm Radiation, Shekhar Guha[1], Joel Murray[1], Jean Wei[1], Kevin T. Zawilski[2], Peter G. Schunemann[2]; [1]*US Air Force Research Lab, USA;* [2]*BAE Systems, USA.* A novel experimental approach, based on re-derivation of the Maker-fringe theory, yielded values d_{14} and d_{36} coefficients of $CdSiP_2$ using a picosecond duration laser tuned between 2700 and 4700 nm.

SF1H.7 • 09:45
High Efficiency Second Harmonic Generation in Gallium Phosphide Ring Resonators on Oxide, Alan Logan[1], Michael Gould[1], Emma Schmidgall[1], Karine Hestroffer[3], Zin Lin[4], Weiliang Jin[2], Arka Majumdar[1], Fariba Hatami[3], Alejandro Rodriguez[2], Kai-Mei Fu[1]; [1]*Univ. of Washington, USA;* [2]*Princeton Univ., USA;* [3]*Humboldt-Universitat zu Berlin, Germany;* [4]*Harvard Univ., USA.* Second harmonic conversion from 1550~nm to 775~nm with an efficiency of 400% W^{-1} is demonstrated in quasi-phase matched ring resonators in a gallium phosphide on oxide integrated photonic platform.

10:00–10:30 Coffee Break, *Concourse Level*

Meeting Room 211 A/B | Meeting Room 211 C/D | Meeting Room 212 A/B | Meeting Room 212 C/D

CLEO: Science & Innovations

SF1I • Frequency-Comb-Based Sensing—Continued

SF1I.4 • 09:00
High-resolution Dual-comb Spectroscopy with a Free-running All-fiber Laser, Lukasz A. Sterczewski[1], Aleksandra Przewloka[2], Wawrzyniec Kaszub[2], Jaroslaw Sotor[1]; [1]*Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland;* [2]*Inst. of Electronic Materials Technology, Poland.* We use a 1.56 µm computationally-corrected polarization-multiplexed dual-comb laser in free-running mode to measure hydrogen cyanide at 10 Torr. The source with a repetition rate of 142.4 MHz requires only 0.35 W of electrical power.

SF1I.5 • 09:15
Quantum Cascade Laser Dual-comb Spectroscopy For Multi-species Detection, Jonas Westberg[1], Lukasz A. Sterczewski[1,2], Gerard Wysocki[1]; [1]*Princeton Univ., USA;* [2]*Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland.* Multi-species detection of analytes in gas-phase by dual-comb spectroscopy using quantum cascade laser frequency combs is demonstrated. These chip-scale, electrically-pumped, semiconductor light sources are highly appealing for portable multi-component chemical spectroscopic sensors.

SF1I.6 • 09:30
GHz Dual-comb Spectroscopy with 110-µs Time Resolution, Nazanin Hoghooghi[1], Ryan K. Cole[1], Amanda Makowiecki[1], Gregory B. Rieker[1]; [1]*Univ. of Colorado Boulder, USA.* We demonstrate high-speed dual-comb spectroscopy by spectrally filtering frequency combs using two Fabry-Perot cavities. Using this system, we measured the spectrum of CO with high signal to noise in 110 µs and 1 GHz resolution.

SF1I.7 • 09:45
Rapid and high-resolution multidimensional coherent spectroscopy using three frequency combs, Bachana Lomsadze[2], Brad Smith[1], Steven T. Cundiff[1]; [1]*Univ. of Michigan, USA;* [2]*Physics, Santa Clara Univ., USA.* We present a novel method, tri-comb spectroscopy, which enables the measurement of a high-resolution multidimensional coherent spectrum in 365 ms. This method has the potential to become a field-deployable device for remote-sensing applications.

SF1J • Plasmonics, Optomechanics, & Metamaterials—Continued

SF1J.4 • 09:00
Dynamical chaos in silicon cavity optomechanics for physically-encrypted secure communications, Jia-Gui Wu[2,1], Jaime G. Flor Flores[2], Qingsong Bai[2], Jinghui Yang[2], Xueyan Xiong[1], Mingbin Yu[3], Guoqiang Lo[3], Shukai Duan[1], Chee Wei Wong[2]; [1]*Southwest Univ., China;* [2]*Fang Lu Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA;* [3]*The Inst. of Microelectronics, 11 Science Park Road, Singapore.* We demonstrate pure physical encrypted communication systems using chaos generated on silicon optomechanical nanocavities. Our chaos synchronization correlation coefficient is high at 0.97, and the Mb/s NRZ messages were decoded with a critical 3×10^{-5} BER.

SF1J.5 • 09:15
Ultrasonic acousto-optical receivers based on optomechanical resonance and oscillation, Ke Huang[1], Mani Hossein-Zadeh[1]; [1]*Univ. of New Mexico, USA.* We experimentally demonstrate that radiation pressure based optomechanical interaction in high-Q cavities can be exploited for high sensitivity acousto-optical transduction and direct signal down-conversion in underwater ultrasonic communication links and sensor networks.

SF1J.6 • 09:30
Waveguide-to-waveguide directional coupling beyond a free space wavelength, Orad Reshef[1], Codey Nacke[1], Jeremy Upham[1], Robert Boyd[1,2]; [1]*Univ. of Ottawa, Canada;* [2]*Univ. of Rochester, USA.* We investigate the use of integrated zero-index metamaterials in directional coupling. Ring resonators incorporating these materials exhibit critical coupling over larger separations than is possible with evanescent coupling, even exceeding the free space wavelength.

SF1J.7 • 09:45
High Tolerance of Metamaterial Waveguides to Fabrication Variations, Moshe Zadka[1], Utsav D. Dave[1], Michal Lipson[1]; [1]*Columbia Univ., USA.* We demonstrate that silicon metamaterial waveguides have a high tolerance to large fabrication variations. We measured only a 5% drop in the Quality factor of a resonator with a metamaterial segment compared to a 40% drop for a wire waveguide segment, with a 50 nm discontinuity.

CLEO: Applications & Technology

AF1K • Structural Monitoring—Continued

AF1K.4 • 09:00
Simple High Performance Polarimetric Fiber-Optic Current Sensor Operated with Different Types of Sensing Fiber, Klaus M. Bohnert[1], Andreas Frank[1], Lin Yang[1], Xun Gu[3], Georg M. Müller[2]; [1]*Corporate Research, ABB Switzerland Ltd, Switzerland;* [2]*Grid Automation, ABB Switzerland Ltd, Switzerland;* [3]*High Voltage Products, ABB Switzerland Ltd, Switzerland.* We investigate a simple polarimetric fiber-optic current sensor with an integrated-optic polarization splitter/combiner for interrogation and coils from spun birefringent fiber and low birefringence fiber. We demonstrate accuracy to within 0.2% between -40 and 85°C.

AF1K.5 • 09:15
Correlation-domain distributed temperature sensing based on enhanced forward Brillouin scattering, Neisei Hayashi[1], Yosuke Mizuno[2], Kentataro Nakamura[2], Chao Zhang[1], Lei Jin[1], Sze Y. Set[1], Shinji Yamashita[1]; [1]*The Univ. of Tokyo, Japan;* [2]*Tokyo Inst. of technology, Japan.* We demonstrate distributed temperature sensing based on enhanced forward Brillouin scattering using a correlation-domain technique. A 104-m-long heated section is clearly detected in a 397-m-long highly nonlinear fiber.

AF1K.6 • 09:30
Intrinsic Fabry-Perot Interferometer Fiber Sensor by Femtosecond Laser Induced Rayleigh Backscattering Enhancement, Zhaoqiang Peng[1], Mohan Wang[1], Sheng Huang[1], Ran Zou[1], Jingyu Wu[1], Qirui Wang[1], Kevin P. Chen[1]; [1]*Univ. of Pittsburgh, USA.* This paper reports enhanced Rayleigh backscattering points fabricated in single-mode fiber using a femtosecond laser direct-writing technique for the formation of an intrinsic Fabry-Perot interferometer (FPI) fiber sensor. The temperature sensitivity of the FPI is measured as 7.8pm/°C.

AF1K.7 • 09:45
94.8 Km-Range Direct Detection Fiber Optic Distributed Acoustic Sensor, Faruk Uyar[1], Talha Onat[1], Canberk Unal[1], Tolga Kartaloglu[1], Ibrahim Ozdur[1], Ekmel Ozbay[1]; [1]*Bilkent Univ. NANOTAM, Turkey.* This work demonstrates an ultra-long range direct detection fiber optic distributed acoustic sensor which can detect vibrations at a distance of 94.8 km with 10 m resolution along the sensing fiber.

CLEO: Science & Innovations

SF1L • Fiber Parametric Sources—Continued

SF1L.5 • 09:00
Broadband Electro-Optic Dual-Comb Interferometer with High-Resolution, Bingxin Xu[1], Xinyu Fan[1], Shuai Wang[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China.* We demonstrate a broadband dual-comb interferometer with high resolution. The combs over 1.5 THz bandwidth with a line spacing of 100 MHz are resolved, and the line spacing can be flexibly adjusted.

SF1L.6 • 09:15
High contrast beating 6 lines to a single branch amplifier-free GHz Yb:fiber laser frequency comb, Yuxuan Ma[1], Fei Meng[1,2], Yan Wang[1], Aimin Wang[1], Zhigang Zhang[1]; [1]*Peking Univ., China;* [2]*National Inst. of Metrology, China.* A 0.95 GHz amplifier-free Yb:fiber laser frequency comb was used to generate single branch super-continuum and to beat with 6 visible and near-infrared lasers in 35 dB to 42 dB signal-to-noise-ratio.

SF1L.7 • 09:30
Generation of Raman Dissipative Solitons in an External Phosphosilicate All-Fiber Cavity, Denis S. Kharenko[1,2], Vlad D. Efremov[2,1], Sergey A. Babin[1,2]; [1]*IAE SB RAS, Russia;* [2]*Novosibirsk State Univ., Russia.* An external-cavity generation of highly-chirped dissipative solitons near 1.3 µm in all-fiber scheme by using a new type of phosphosilicate polarization maintaining fiber is investigated. The pulses were compressed down to 570 fs.

10:00–10:30 Coffee Break, *Concourse Level*

CLEO: Science & Innovations

SF1M • Fiber-Based Information Process—Continued

SF1M.4 • 09:00
Multiple Modal and Wavelength Conversion Process of a 10-Gbit/s Signal in a 6-LP-Mode Fiber, Haisu Zhang[1], Marianne Bigot-Astruc[2], Laurent Bigot[3], Pierre Sillard[2], Julien Fatome[1]; [1]*CNRS - Universite Bourgogne Franche Comté, France;* [2]*Prysmian Group, France;* [3]*IRCICA - Université de Lille, France.* We experimentally demonstrate a simultaneous threefold modal and wavelength conversion process of a 10-Gbit/s NRZ signal in a 1.8-km long 6-LP-mode fiber. The principle of operation is based on a phase-matched intermodal four-wave mixing phenomenon.

SF1N • AI for Integrated Photonics—Continued

SF1N.4 • 09:00
Optoelectronic Quantum Capacitors for Configurable Neural Photonic Networks, Pouya Dianat[1], Anna Persano[2], Fabio Quaranta[2], Adriano Cola[2], Bahram Nabet[1]; [1]*Drexel Univ., USA;* [2]*IMM-CNR, Italy.* An optoelectronic quantum capacitor is described as a memristive behaving neuron in a dynamically configurable crossbar network. Activation, weight, and bias for each neuron are dynamically controlled with light, gate voltage, and a sampling frequency, respectively.

SF1N.5 • 09:15
SOA-Based Photonic Integrated Deep Neural Networks for Image Classification, Bin Shi[1], Nicola Calabretta[1], Ripalta Stabile[1]; [1]*Inst. for Photonic Integration, Eindhoven Univ. of technology, Netherlands.* We successfully demonstrate classification of three classes of Iris flowers by implementing a trained neural network on an SOA-based InP cross-connect chip. Classification accuracy of 91.6% is achieved after a fine optimization procedure.

SF1N.6 • 09:30
Towards Optical Neural Networks with Fabrication Noise Immunity, Michael Fang[1,2], Sasikanth Manipatruni[4], Casimir Wierzynski[3], Amir Khosrowshahi[3], Ian Young[4]; [1]*Physics, UC Berkeley, USA;* [2]*Redwood Center for Theoretical Neuroscience, UC Berkeley, USA;* [3]*AI Research, Intel, USA;* [4]*Components Research, Intel, USA.* Optical neural networks (ONNs) can provide breakthrough energy/op and latency compared to GP-GPUS/ASICs. Here we compare two different architectures of ONNs and explore the effect of the imprecision of constituent photonic components.

SF1O • Perovskites—Continued

SF1O.4 • 09:00
Modulation of $CH_3NH_3PbBr_3$ perovskite microcrystal morphology for WGM and F-P mode lasers, Bobo Li[1]; [1]*CUHKSZ, China.* We focused on the growth of $CH_3NH_3PbBr_3$ perovskite crystals with shapes of sub-circular and quasi-cubic under different temperatures for WGM and F-P mode lasers. The lasing emissions exhibit low threshold below 20 μJ/cm^2.

SF1O.5 • 09:15
Simultaneous Inhibition and Redistribution of Spontaneous Emission from Perovskite Photonic Crystals, Songyan Hou[1,2], Teo Hang Tong Edwin[1,2], Muhammad Danang Birowosuto[2], Hong Wang[1,2]; [1]*Nanyang Technological Univ., Singapore;* [2]*CINTRA, Singapore.* Here, perovskite PhC exhibits both emission rate inhibition and light energy redistribution simultaneously, as a result of light energy redistribution from 2D guided modes to vertical direction, indicating a high intrinsic light extraction efficiency.

SF1O.6 • 09:30
Quantum-confined Stark effect of lead halide perovskite quantum dots in a mixed dimensional van der Waals heterostructure, Chitraleema Chakraborty[1], Hendrik Utzat[2], Matthias Ginterseder[2], Hyowon Moon[1], Cheng Peng[1], Moungi Bawendi[2], Dirk R. Englund[1]; [1]*Electrical Engineering and Computer Science, MIT, USA;* [2]*Dept. of Chemistry, MIT, USA.* We demonstrate quantum-confined Stark effect in perovskite quantum dots by employing a voltage-tunable vertically stacked van der Waals heterostructure with 2D materials. A spectral shift of 10 meV was observed for the exciton peak.

10:00–10:30 Coffee Break, *Concourse Level*

CLEO: QELS-Fundamental Science

Executive Ballroom 210A

10:30–12:30
FF2A • Photonic Crystals & Periodic Nano Optics
Presider: Sushil Mujumdar; Tata Institute of Fundamental Research, India

FF2A.1 • 10:30
High Reflection from a One-Dimensional Array of Graphene Nanoribbons, Nathan Z. Zhao[1], Zhexin Zhao[1], Ian Williamson[1], Salim Boutami[1], Bo Zhao[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We show one-dimensional plasmonic systems such as graphene nanoribbons can be used to engineer extremely large bandwidth, high reflectivity resonances. Further, we prove that the underlying concept relies upon the general observation of the lack of Chu-Harrington limit in one-dimensional systems.

FF2A.2 • 10:45
Photonic Crystal Polaritons in 2D Materials, Rahul Gogna[1], Long Zhang[1], Hui Deng[1]; [1]*Univ. of Michigan, USA.* We demonstrate the important properties of transition-metal dichalcogenides strongly coupled to one-dimensional photonic crystals, including the design considerations and dispersions, as well as the possibility for creating multi-wavelength polariton devices on a single chip.

FF2A.3 • 11:00
Free-Space Modulators Based on Dimerized High Contrast Gratings, Stephanie C. Malek[1], Adam C. Overvig[1], Sajan Shrestha[1], Nanfang Yu[1]; [1]*Columbia Univ., USA.* We investigate periodic symmetry breaking as a method of controlling Fano resonances in high contrast dielectric gratings with small device footprints and report experimental and computational demonstrations of free-space modulators based on these dimerized gratings.

Executive Ballroom 210B

10:30–12:30
FF2B • Linear/Non-Linear Metasurfaces
Presider: To Be Announced

FF2B.1 • 10:30
Non-resonant Enhancement of Second-Harmonic Generation in a Dielectric Particle with a Nanostructured Nonlinear Metamaterial Shell, Joong Hwan Bahng[1], Douglas Montjoy[2], Saman Jahani[1], Nicholas Kotov[2], Alireza Marandi[1]; [1]*California Inst. of Technology, USA;* [2]*Univ. of Michigan, Ann Arbor, USA.* We demonstrate a new principle for realizing a miniaturized and scalable platform for nonlinear optics using dielectric particles with nanostructured nonlinear metamaterial shells. We show numerical and experimental results of enhanced second-harmonic generation in them.

FF2B.2 • 10:45
All-Optical Tuning of Fano Resonances in Broken-Symmetry GaAs Metasurfaces, Nicholas Karl[1,2], Polina Vabishchevich[1,2], Sheng Liu[1,2], Michael B. Sinclair[1], Gordon Keeler[1], Gregory Peake[1], Igal Brener[1,2]; [1]*Sandia National Labs, USA;* [2]*Center for Integrated Nanotechnologies, Sandia National Labs, USA.* We demonstrate ultrafast tuning of Fano resonances in a broken symmetry III-V metasurface using optical pumping. The resonance is spectrally shifted by 10 nm under low pump fluences of < 100 uJ cm^{-2}.

FF2B.3 • 11:00
Dielectric nanocavities with enhanced local density of states, Sandro Mignuzzi[1], Javier Cambiasso[1], Stefano Vezzoli[1], Simon A. Horsley[2], William Barnes[2], Stefan Maier[1], Riccardo Sapienza[1]; [1]*Imperial College London, UK;* [2]*Exeter Univ., UK.* We demonstrate all-dielectric single photon nanocavities by rational design of the local density of optical states. We unravel an inverse design route to strong emitter's decay rate enhancements, near-unity quantum efficiency, and large bandwidth.

Executive Ballroom 210C

10:30–12:30
FF2C • Attosecond Pulse Generation & Characterization
Presider: Wendell T. Hill, III; Univ. of Maryland, USA

FF2C.1 • 10:30
Reduction of Laser-Intensity-Correlated Noise in High-Harmonic Generation, Mikhail Volkov[1], Justinas Pupeikis[1], Christopher Phillips[1], Fabian Schlaepfer[1], Lukas Gallmann[1], Ursula Keller[1]; [1]*ETH Zurich, Switzerland.* We present a scheme for correcting the spectral fluctuations of high-harmonic radiation by monitoring the generating near-infrared pulse energy. We apply this correction in an attosecond transient absorption experiment yielding an improved confidence interval on the mean.

FF2C.2 • 10:45
Temporal Coherence of Linearly and Circularly Polarized High-Harmonics from Silicon, Nicolai Klemke[1,2], Nicolas Tancogne-Dejean[1,3], Giulio Maria Rossi[1,2], Yudong Yang[1,4], Roland E. Mainz[1,2], Angel Rubio[1,3], Franz Kärtner[1,2], Oliver D. Mücke[1,4]; [1]*Center for Free-Electron Laser Science CFEL, Deutsches Elektronen Synchrotron DESY, Germany;* [2]*Physics Dept., Univ. of Hamburg, Germany;* [3]*Max Planck Inst. for the Structure and Dynamics of Matter, Germany;* [4]*The Hamburg Centre for Ultrafast Imaging CUI, Germany.* Circularly polarized high-harmonics can be generated from solids with elliptical and circular driver polarization. We investigate the temporal coherence properties of both cases and compare them to those of linearly polarized high-harmonics.

FF2C.3 • 11:00
Controlling HHG with a Sub-Cycle mJ-Level Parametric Waveform Synthesizer, Yudong Yang[1,2], Giulio Maria Rossi[1,2], Roland E. Mainz[1], Fabian Scheiba[1], Giovanni Cirmi[1,2], Franz Kärtner[1,2]; [1]*Deutsches Elektronen-Synchrotron DESY, Germany;* [2]*The Hamburg Centre for Ultrafast Imaging CUI, Germany.* We present HHG driven with a sub-cycle mJ-level parametric waveform synthesizer. The variation of the HHG spectral shape and yield as a function of the relative phase between the synthesizer channels is shown.

Executive Ballroom 210D

10:30–12:30
FF2D • Frequency Comb & Supercontinuum Generation
Presider: To Be Announced

FF2D.1 • 10:30
Advanced dispersion engineering of dispersive waves in Si3N4microresonators, Fabien Gremion[1], Anton Lukashchuk[1], Maxim Karpov[1], Junqiu Liu[1], Tobias J. Kippenberg[1]; [1]*EPFL, LPQM, Switzerland.* We experimentally demonstrate the possibility of dispersive wave tuning via advanced dispersion engineering. We utilize hybridized modes of concentric coupled resonators for precise control of the dispersion profile.

FF2D.2 • 10:45
Multi-phase-matched satellite frequency combs, Jinghui Yang[1], Shu-Wei Huang[2], Zhenda Xie[5], Mingbin Yu[3,4], Dim Lee Kwong[3], Chee Wei Wong[1]; [1]*Univ. of California Los Angeles, USA;* [2]*Univ. of Colorado Boulder, USA;* [3]*Inst. of Microelectronics, Singapore;* [4]*Shanghai Inst. of Microsystem and Information Technology, China;* [5]*School of Electronic Science and Engineering, Nanjing Univ., China.* We report Kerr frequency combs with satellite clusters spanning beyond conventional phase-matching bandwidth. The evolution of the signal and idler satellites at ≈ 1.3 mm and 1.9 mm regimes are detailed. With proper pump parameters, the satellites can span up to one full octave.

FF2D.3 • 11:00
Microresonator frequency comb generation with simultaneous Kerr and electro-optic nonlinearities, Mian Zhang[1,2], Christian Reimer[1], Lingyan He[1], Rebecca H. Cheng[1], Mengjie Yu[1], Rongrong Zhu[3], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*HyperLight Corporation, USA;* [3]*Electrical Engineering, Zhejiang Univ., China.* We experimentally investigate electro-optic (EO) modulation of a dispersion engineered lithium niobate microring resonator under a strong optical pump. We show that EO modulated Kerr comb spectrum is significantly broader than with either Kerr or EO nonlinearity alone.

Executive Ballroom 210E

CLEO: Science & Innovations

10:30–12:30
SF2E • Ultrafast Phenomena
Presider: Guangjin Ma, DESY, Germany

SF2E.1 • 10:30 Tutorial
Harnessing Quantum Light Science for Applications in Materials and Nano Science, Margaret M. Murnane[1]; [1]*Univ. of Colorado at Boulder, USA.* High harmonic generation produces polarization-shaped extreme-ultraviolet and soft X-ray beams that can uncover the fastest charge, spin and lattice dynamics in quantum materials, and enable high-contrast non-destructive imaging of opaque materials at the wavelength limit.

Dr. Margaret Murnane is Director of the US National Science Foundation STROBE Science and Technology Center on functional nanoimaging, a Fellow at JILA and a member of the Departments of Physics and Electrical and Computer Engineering at the University of Colorado. She received her B.S and M.S. degrees from University College Cork, Ireland, and her Ph.D. degree in physics from the University of California at Berkeley in 1989. She runs a joint research group with her husband, Prof. Henry Kapteyn. Margaret's research interests have been in ultrafast laser and x-ray science. She is a Fellow of the American Physical Society, The Optical Society and the AAAS. Her honors include the Maria Goeppert-Mayer Award of the American Physical Society, a John D. and Catherine T. MacArthur Fellowship, and election to the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and the Royal Irish Academy. She has done extensive service, including serving as Chair of the President's Committee for the (US) National Medals of Science. She is the 2017 recipient of the Ives Medal/ Quinn Prize of The Optical Society—the OSA's highest honor.

Executive Ballroom 210F

Joint

10:30–12:30
JF2F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect II

JF2F.1 • 10:30 Invited
Phase Compensation for Continuous Variable Quantum Key Distribution, Hou-Man Chin[1], Darko Zibar[1], Nitin Jain[1], Tobias Gehring[1], Ulrik Andersen[1]; [1]*Technical Univ. of Denmark, Denmark.* The tracking and compensation of phase noise is critical to reducing excess noise for continuous variable quantum key distribution schemes. This work demonstrates the effectiveness of unscented Kalman filter for phase noise compensation.

JF2F.2 • 11:00 Invited
Deep Learning in Optical Microscopy and Image Reconstruction, Aydogan Ozcan[1]; [1]*Univ. of California Los Angeles, USA.* We will discuss recently emerging applications of the state-of-art deep learning methods on optical microscopy and microscopic image reconstruction, which enable new transformations among different modalities of microscopic imaging, driven entirely by image data. We believe that deep learning will fundamentally change both the hardware and image reconstruction methods used in optical microscopy and sensing in a holistic manner.

Executive Ballroom 210G

CLEO: Science & Innovations

10:30–12:30
SF2G • Laser-Based Diagnostics for Material Processing
Presider: Ed Kinzel; Uni. of Notre Dame, USA

SF2G.1 • 10:30
Enantio-enrichment of Racemic Films Using Circularly Polarized Femtosecond Pulses, Katrin E. Oberhofer[1], Farinaz Mortaheb[2], Johann Riemensberger[1], Florian Ristow[1], Reinhard Kienberger[1], Ulrich K. Heiz[2], Hristo Iglev[1], Aras Kartouzian[2]; [1]*Physics Dept., Technical Univ. of Munich, Germany;* [2]*Catalysis Research Center, Chair of Physical Chemistry, Technical Univ. of Munich, Germany.* Circularly polarized laser pulses are used to desorb chiral molecules enantioselectively from an achiral surface implicating the quantum mechanical nature of this process, moreover demonstrating a new method for enantio-enrichment and enantio-separation.

SF2G.2 • 10:45
Two Dimensional Film Printing by Blister-Based Laser-Induced Forward-Transfer, Nathan T. Goodfriend[1], Oleg Nerushev[2], Wenshuo Xu[3], Mitsuhiro Okada[4], Ryo Kitaura[4], Jamie Warner[3], Hisanori Shinohara[4], Alexander Bulgakov[1], Eleanor Campbell[2,5], Nadezhda M. Bulgakova[1]; [1]*HiLASE, Czechia;* [2]*School of Chemistry, EastCHEM, UK;* [3]*Dept. of Materials, Univ. of Oxford, UK;* [4]*Dept. of Chemistry, Nagoya Univ., Japan;* [5]*Konkuk Univ., South Korea (the Republic of).* An investigation into the feasibility of using ultrashort laser pulses to induce deformations on a donor film coated in 2 dimensional materials as a printing technique for the contactless and impurity-free fabrication of devices based on these materials.

SF2G.3 • 11:00 Invited
Non-Equilibrium Structural Dynamics in Laser-Driven Materials Studied with Time-Resolved Diffraction, Klaus Sokolowski-Tinten[1]; [1]*Universität Duisburg-Essen, Germany.* This talk will discuss some of our recents results on using time-resolved diffraction with femtosecond X-ray or electron pulses to investigate the non-equilibrium structural response of materials upon intense ultrafast optical excitation.

Executive Ballroom 210H

10:30–12:30
SF2H • Active & Reconfigurable Devices
Presider: Vivek Shrestha; Univ. of Melbourne, Australia

SF2H.1 • 10:30 Invited
Topological Phenomena in Active Photonic Platforms, Mercedeh Khajavikhan[1]; [1]*Univ. of Central Florida, CREOL, USA.* Active photonics provides a unique set of opportunities for realizing and harvesting topological phenomena in optics. We will review the recent advances in this field and discuss some of the challenges ahead.

SF2H.2 • 11:00
Photon-level tuning of a high-Q lithium niobate photonic crystal nanocavity, Mingxiao Li[1], Hanxiao Liang[1], Rui Luo[1], Yang He[1], Jingwei Ling[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA.* We report an all-optical approach for extremely efficient tuning of a high-Q lithium niobate photonic crystal nanocavity, with a significant resonance tuning rate of 110~MHz/photon.

Meeting Room 211 A/B

Meeting Room 211 C/D

Meeting Room 212 A/B

Meeting Room 212 C/D

CLEO: Science & Innovations

10:30–12:30
SF2I • High Q Cavity, Resonators Application
Presider: Haisheng Rong; Intel Corporation, USA

SF2I.1 • 10:30
Tunable Optomechanical Cavity Filters, Marcel W. Pruessner[1], Doewon Park[1], Brian Roxworthy[1], Dmitry Kozak[1], Todd Stievater[1], Nathan Tyndall[1], William Rabinovich[1]; [1]*US Naval Research Lab, USA.* Cavity optomechanics enables large-scale index tuning (Δn_{eff}). However, most demonstrations exhibited small Δn_{eff} or have not considered optical loss at large Δn_{eff}. We demonstrate Δn_{eff}-tuning using gradient electric forces and analyze optomechanically-induced loss and mitigation.

SF2I.2 • 10:45
High Q resonators in the GaAs and AlGaAs on insulator platform, Lin Chang[1], Andreas Boes[1,2], Paolo Pintus[1], Jon Peters[1], MJ Kennedy[1], Warren Jin[1], Xiaowen Guo[1], Supeng Yu[3], Scott B. Papp[3], John Bowers[1]; [1]*Univ. of California Santa Barbara, USA;* [2]*RMIT, Austria;* [3]*NIST, USA.* We demonstrated a low loss gallium arsenide (GaAs) and aluminum gallium arsenide (AlGaAs) on insulator platform by heterogenous integration. The ring resonators on this platform exhibit record high intrinsic quality factors above 1×10^6.

SF2I.3 • 11:00 Invited
Explore Whispering-gallery Resonators for a Versatile Sensor Platform, Lan Yang[1]; [1]*Washington Univ. in St Louis, USA.* I will talk about opportunities of whispering-gallery-mode resonators tailored in different geometries for various sensing applications. Their potential as a new generation of sensing platform for the Internet of Things applications will be discussed.

10:30–12:30
SF2J • Lithium Niobate & Perovskite Photonic Devices
Presider: Christian Reimer; HyperLight Corporation, USA

SF2J.1 • 10:30
Ultra-Low Loss Integrated Lithium Niobate Photonics in Visible Wavelengths, Boris Desiatov[1], Amirhassan Shams-Ansari[1], Mian Zhang[1,2], Cheng Wang[3], Marko Loncar[1]; [1]*Harvard Univ., USA;* [2]*HyperLight Corporation, USA;* [3]*Dept. of Electronic Engineering, City Univ. of Hong Kong, Hong Kong.* We demonstrate a low loss integrated photonic platform in lithium niobate in the visible wavelength range. We show microring resonators with a quality factor of 10^7 and gigahertz intensity modulators.

SF2J.2 • 10:45
Perovskite Micro Laser arrays using Scalable Lithography: Towards Integrated Perovskite Photonics, Ofer Bar-On[1], Philipp Brenner[2], Uli Lemmer[2], Jacob Scheuer[1]; [1]*Tel-Aviv Univ., Israel;* [2]*Karlsruhe Inst. of Technology, Germany.* Low threshold Perovskite micro lasers are fabricated and characterized. These devices are realized using the first complete top-down lithography process of metal halide perovskites which presents a crucial step towards integrated perovskite photonics.

SF2J.3 • 11:00
Low-loss waveguides in Y-cut thin film lithium niobate for acousto-optic applications, Lutong Cai[1], Gianluca Piazza[1]; [1]*Carnegie Mellon Univ., USA.* The dependence of waveguide loss on buried oxide thickness in Y-cut lithium niobate on insulator (an ideal platform for acousto-optic devices) was investigated. Waveguide loss of as low as 0.33 dB/cm was measured.

CLEO: Applications & Technology

10:30–12:30
AF2K • Spectrometers & Wavelength Metrology
Presider: Kara Peters; North Carolina State University, USA

AF2K.1 • 10:30
Microresonator Spectrometer Using Counter-propagating Solitons, Qi-Fan Yang[1], Boqiang Shen[1], Heming Wang[1], Minh Tran[2], Zhewei Zhang[1], Kiyoul Yang[1], Lue Wu[1], Chengying Bao[1], John Bowers[2], Amnon Yariv[1], Kerry J. Vahala[1]; [1]*T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA.* A spectrometer is demonstrated using self-locked counter-propagating soliton frequency combs in a high-Q silica microresonator. Fast tuning laser waveforms and molecular absorption features are measured with kiloHertz to MegaHertz resolution.

AF2K.2 • 10:45
All-fiber Electro-optic Frequency Comb for Near-Infrared Astronomical Spectrograph Calibration, Ewelina Obrzud[1,2], Victor Brasch[1], Steve Lecomte[1], François Wildi[2], François Bouchy[2], Francesco Pepe[2], Tobias Herr[1]; [1]*Centre Suisse d'Electronique et de Micro, Switzerland;* [2]*Astronomy, Univ. of Geneva, Switzerland.* A turn-key, all-fiber 14.5 GHz electro-optic modulation-based near-infrared frequency comb spanning 700 nm for astronomical spectrograph calibration is developed, capable of providing radial velocity calibration with a precision of < 10 cm/s, relevant for exoplanet searches.

AF2K.3 • 11:00
Increasing the Range and Precision of Integrated Wavemeters, Enrique Martin-Lopez[1], David Bitauld[1]; [1]*Nokia Bell Labs, UK.* We demonstrate an integrated wavemeter concept enabling high and wavelength-independent precision over increased spectrum ranges while avoiding ambiguities from the spectrally periodic response. This versatile device can significantly improve the control of integrated tunable lasers.

CLEO: Science & Innovations

10:30–12:30
SF2L • MID-IR Fiber Sources
Presider: Maria Chernysheva; Leibniz Institute of Photonic Technology, Germany

SF2L.1 • 10:30
Ultrafast mid-infrared fiber lasers beyond 3 µm, Simon Duval[1,2], Yuchen Wang[3,4], Louis-Rafaël Robichaud[1,2], Michel Olivier[1,5], Frédéric Jobin[1], Jean-Christophe Gauthier[1], Pascal Paradis[1], Vincent Fortin[1], Paolo Laporta[3,4], Martin Bernier[1], Michel Piché[1], Gianluca Galzerano[3,4], Réal Vallée[1]; [1]*Universite Laval, Canada;* [2]*Femtum inc., Canada;* [3]*Dipartimento di Fisica, Politecnico di Milano, Italy;* [4]*Istituto di Fotonica e Nanotecnologie, Italy;* [5]*Département de physique, Cégep Garneau, Canada.* We present recent demonstrations of fiber oscillators and amplifiers based on erbium- and dysprosium-doped fluoride fibers that enable the generation of ultrashort pulses above 3 µm.

SF2L.2 • 11:00
~3.5 µm self-Q-switched Er3+:ZBLAN fiber laser stabilized by an ASE seeded pump source, Jun Liu[1], Jiadong Wu[1], Pinghua Tang[1], Yu Chen[1], Dianyuan Fan[1]; [1]*Shenzhen Univ., China.* We report on a ~3.5 µm highly stable self-Q-switched Er^{3+}:ZBLAN fiber laser based on a temporally stable ASE seeded pump source. The pulsing dynamics are carefully investigated which can help facilitate their potential applications.

Marriott
Salon I & II

Joint

10:30–12:30
JF2M • Professional Development Session II

Optimizing Career Paths in Optics: the Guide for Young Professionals

Career planning is very important for young professionals in optics. Different career paths are available, each with its own requirements, challenges, and rewards. We invite young professionals to hear firsthand from their more seasoned colleagues about their jobs. Practical questions on how to excel in an optics-related career will be answered. What does it take to get a foot in the door at your target workplace? How to network? Who makes hiring decisions, and how? What qualities are the most sought? What does it get not to get stuck in your career? How could your typical workday look like? What are the most common challenges in maintaining the work-life balance?

Panelists:

J. Stewart Aitchison, *University of Toronto, Canada*
Sterling Backus, *KMLabs, USA*
Ben Eggleton, *University of Sydney, USA*
Tara Fortier, *National Institute of Standards and Technology, USA*
Michael Mielke, *Iradion Laser Inc., USA*
Irina Novikova, *College of William and Mary, USA*
Sergey Polyakov, *National Institute of Standards and Technology. USA*
Stephanie Tomasulo, *U.S. Naval Research Laboratory, USA*

Marriott
Salon III

CLEO: Science & Innovations

10:30–12:30
SF2N • RF Photonics
Presider: Ozdal Boyraz; Univ. of California Irvine, USA

SF2N.1 • 10:30
High-Speed Photodetection and Microwave Generation in a Sub-100 mK Environment, Josue Davila-Rodriguez[1], John D. Teufel[1], José A. Aumentado[1], Xiaojun Xie[3], Joe C. Campbell[3], Scott A. Diddams[1,2], Franklyn Quinlan[1,2]; [1]*NIST, USA;* [2]*Dept. of Physics, Univ. of Colorado, USA;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Virginia, USA.* We perform microwave generation via high-speed photodetection at a temperature of 20 mK. Shot noise-limited detection with high linearity was obtained, compatible with continued scaling of the control and readout of superconducting quantum information systems.

SF2N.2 • 10:45
Broadband Local Oscillator Free Photonic Microwave Mixer based on a Coherent Kerr Micro-Comb Source, Jiayang Wu[1], Xingyuan Xu[1], Mengxi Tan[1], Thach Nguyen[2], Sai Chu[3], Brent Little[4], Roberto Morandotti[5], Arnan Mitchell[2], David Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*RMIT Univ., Australia;* [3]*City Univ. of Hong Kong, China;* [4]*Chinese Academy of Science, China;* [5]*INSR-Énergie, Matériaux et Télécommunications, Canada.* We demonstrate a photonic microwave mixer based on an integrated micro-comb source. We achieve an operation bandwidth of over 40 GHz with a conversion efficiency of −6.8 dB and a spurious suppression ratio of 43.5 dB.

SF2N.3 • 11:00
Experimental Characterization of Low-Latency Multiple and Tunable Delays of Wideband Analog LFM Signal Using Concatenated Linearly Chirped and Sampled FBGs, Ahmed Almaiman[1], Yinwen Cao[1], Fatemeh Alishahi[1], Ahmad Fallahpour[1], Long Li[1], Peicheng Liao[1], Kaiheng Zou[1], Shlomo Zach[2], Nadav Cohen[2], Moshe Tur[2], Alan E. Willner[1]; [1]*Univ. of Southern California, USA;* [2]*School of Electrical Engineering, Tel Aviv Univ., Israel.* Concatenated chirped and sampled fiber Bragg gratings are used to simultaneously generate multiple wavelength-tunable delayed versions of a wide bandwidth (10GHz) analog linear-frequency-modulated (LFM) pulse. We measured peak sidelobe level (PSL) > 31 dB.

Marriott
Salon IV

10:30–12:30
SF2O • Optoelectronic Materials
Presider: Oana Malis; Purdue Univ., USA

SF2O.1 • 10:30
Electrical Characterization of Solar-Blind Deep-Ultraviolet $(Al_{0.28}Ga_{0.72})_2O_3$ Schottky Photodetectors Grown on Silicon by Pulsed Laser Deposition, Nasir Alfaraj[1], Kuang-Hui Li[1], Chun Hong Kang[1], Davide Priante[1], Laurentiu Braic[1], Zaibing Guo[1], Tien Khee Ng[1], Xiaohang Li[1], Boon S. Ooi[1]; [1]*King Abdullah Univ of Sci & Technology, Saudi Arabia.* This study reports on $(Al_{0.28}Ga_{0.72})_2O_3$-based ultraviolet-C Schottky metal–semiconductor–metal and metal–insulator–metal photodetectors with peak responsivities of 1.17 and 0.40 A/W, respectively, for an incident-light wavelength of 230 nm at 2.50 V reverse-bias.

SF2O.2 • 10:45
The Aging Study for Fine Pitch Quantum-Dot Array on LEDs, Yu-Ming Huang[1], Kai-Ling Liang[2], Yu-Yun Cho[1], Shun-Chieh Hsu[1], Wei-Hung Kuo[2], Chung-Ping Huang[1], Hao-Chung Kuo[3], Yen-Hsiang Fan[2], Chien-Chung Lin[1]; [1]*National Chiao-Tung Univ., Taiwan, Taiwan;* [2]*Industrial Technology Research Inst. of Taiwan, Taiwan;* [3]*National Chiao-Tung Univ., Taiwan.* In this paper, we fabricated the photoresist mold whose pitch is smaller than 15 mm on light-emitting diode and printed two different cadmium-based quantum dots. Also, we burn-in the LED to compare their lifetime which are pasted barrier film by two different methods.

SF2O.3 • 11:00
Nanoscale inspection of GaN LED devices using $g^{(2)}$ cathodoluminescence imaging, Toon Coenen[2,1], Sophie Meuret[2], Yong-Ho Ra[3], Zetian Mi[4], Albert Polman[2]; [1]*Delmic, Netherlands;* [2]*Center for nanophotonics, AMOLF, Netherlands;* [3]*Dept. of Electrical and Computer Engineering, McGill Univ., Canada;* [4]*Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA.* We apply a combination of hyperspectral cathodoluminescence and $g^{(2)}$ imaging to bulk and nanostructured LED materials. From these measurements we extract both excited state lifetimes and the probability of excitation of a single primary electron.

CLEO: QELS-Fundamental Science

FF2A • Photonic Crystals & Periodic Nano Optics—Continued

FF2A.4 • 11:15
Beyond the Goos–Hänchen Effect: Resonance-Induced Spatial Reshaping and its Application in Measuring Resonance Linewidth, Wei Zhang[1], Aaron Charous[1], Masaya Nagai[2], Daniel M. Mittleman[1], Rajind Mendis[1]; [1]*School of Engineering, Brown Univ., USA;* [2]*Graduate School of Engineering Science, Osaka Univ., Japan.* We study the spatial distribution of a beam as it interacts with a planar resonator. Our result encompasses the familiar Goos–Hänchen effect and more complicated scenarios, and can be used for measuring resonance linewidth.

FF2A.5 • 11:30
Symmetry-Broken High Contrast Gratings, Adam C. Overvig[1], Stephanie Malek[1], Sajan Shrestha[1], Nanfang Yu[1]; [1]*Columbia Univ., USA.* We develop an exhaustive catalogue detailing the behavior of normally incident light on symmetry-broken high-contrast gratings. This provides a high-level roadmap for designing compact devices with sharp spectral features within standard nanofabrication constraints.

FF2A.6 • 11:45
Strong Coupling and Bound States in the Continuum in Hybrid Photonic-Plasmonic Structure, Shaimaa Azzam[1], Vladimir M. Shalaev[1], Alexandra Boltasseva[1], Alexander Kildishev[1]; [1]*Purdue Univ., USA.* Strong coupling of the photonic and plasmonic modes in a hybrid structure leads to the formation of bound states in the continuum (BICs) with exceptionally high quality factors.

FF2B • Linear/Non-Linear Metasurfaces—Continued

FF2B.4 • 11:15
Nonlinear Generation of Vacuum Ultraviolet Light with an All-Dielectric Metasurface, Ming Lun Tseng[2,1], Michael Semmlinger[3], Jian Yang[3], Ming Zhang[3], Chao Zhang[3], Peter Nordlander[3], Naomi Halas[3], Din Ping Tsai[2]; [1]*National Taiwan Univ., Taiwan;* [2]*Research Center for Applied Science, Academia Sinica, Taiwan;* [3]*Dept. of Electrical and Computer Engineering, Rice Univ., USA.* An all-dielectric metasurface device for nonlinear generation of coherent vacuum ultraviolet will be is reported. The metasurface made has a resonance at 394 nm and can efficiently generate vacuum ultraviolet under ultrafast laser illumination.

FF2B.5 • 11:30
Optical Needle with Ultra-Small Resolution Enabled by Integrated Metalens, Haowen Liang[1], Qian Sun[1], Yuhao Ren[1], Juntao Li[1]; [1]*Sun Yat-sen Univ., China.* We present a metalens composed of integrated metasurfaces to achieve an optical needle with ultra-small optical resolution of λ/5. This metalens is promising for non-intrusive, far-field super-resolution optical imaging.

FF2B.6 • 11:45
Terahertz Single-Pixel Imaging System with Electrically Tunable Metamaterial Spatial Light Modulator, Wonwoo Lee[1], Hyunseung Jung[2], Hyunwoo Jo[3], Moon Sung Kang[3], Hojin Lee[1,2]; [1]*Dept. of Information Communication, Materials, and Chemistry Convergence Technology, Soongsil Univ., South Korea (the Republic of);* [2]*School of Electronic Engineering, Soongsil Univ., South Korea (the Republic of);* [3]*Dept. of Chemical Engineering, Soongsil Univ., South Korea (the Republic of).* We propose a novel terahertz single-pixel imaging system with active metamaterial spatial light modulator using ion-gel gating graphene. From the experimental results, we confirmed the reconstructed image was 93% of agreement with the real image.

FF2C • Attosecond Pulse Generation & Characterization—Continued

FF2C.4 • 11:15
Attosecond Phase Retrieval by Deep Neural Network, Jonathon White[1], Zenghu Chang[1]; [1]*Univ. of Central Florida, USA.* A deep neural network is used for attosecond pulse phase retrieval. Combination of supervised and unsupervised learning show potential for a fast and accurate phase retrieval method without making the central momentum approximation.

FF2C.5 • 11:30
Generation and Characterization of Attosecond Pulses from an X-ray Free-electron Laser, Siqi Li[1], Philipp Rosenberger[2], Elio Champenois[3], Taran Driver[4], Phil Bucksbaum[3], Ryan Coffee[5], Averell Gatton[5], Gregor Hartmann[6], Wolfram Helml[7], Zhirong Huang[1], Jonas Knurr[3], Matthias Kling[2,3], Ming-Fu Lin[5], James MacArthur[1], Timothy Maxwell[1], Megan Nantel[1], Adi Natan[3], Jordan O'Neal[3], Niranjan Shivaram[5], Peter Walter[5], Thomas Wolf[3], James Cryan[3,5], Agostino Marinelli[1]; [1]*SLAC National Accelerator Lab, USA;* [2]*Dept. of Physics, Ludwig-Maximiliams-Universitat, Germany;* [3]*Stanford PULSE Inst., SLAC National Accelerator Lab, USA;* [4]*Imperial College London, UK;* [5]*Linac Coherent Light Source, SLAC National Accelerator Lab, USA;* [6]*Institut fur physik und CINSaT, Universitat Kassel, Germany;* [7]*Max Planck Inst. of Quantum Optics, Germany.* In this report we discuss the generation of attosecond soft-x-ray pulses at Linac Coherent Light Source (LCLS). We meausre the attosecond pulses in time domain by the method of angular streaking.

FF2D • Frequency Comb & Supercontinuum Generation—Continued

FF2D.4 • 11:15
Experimental evidence of gain-through-loss mechanism in passive fiber ring cavities : toward tunable frequency comb generation, Arnaud Mussot[1], Matteo Conforti[1], Alexandre Kudlinski[1], Florent Bessin[1], Auro Peregro[2], Sergei K. Turitsyn[2], Kestutis Staliunas[3]; [1]*Univ. of Lille Laboratoire PhLAM, France;* [2]*Aston Inst. of Photonic Technologies, Aston Univ., UK;* [3]*Institucio Catalana de Recerca i Estudis Avancat, Spain.* We experimentally demonstrate a novel method based on the gain-throughlosses modulation instability process to generate frequency combs with tunable repetition rate in a normal dispersion externally driven passive fibre resonator.

FF2D.5 • 11:30
Overcoming Spectral Stagnation in Supercontinuum Generation, Haider Zia[1], Niklas M. Lüpken[2], Tim Hellwig[2], Carsten Fallnich[2,1], Klaus J. Boller[1,2]; [1]*Universiteit Twente, Netherlands;* [2]*Westfälische Wilhelms-Universität Münster, Germany.* We present a new approach that increases bandwidth of supercontinuum generation by alternating the sign of dispersion along the interaction length, bypassing mechanisms that limit bandwidth in typical approaches. The method should be particularly suited for fiber and integrated optical waveguides.

FF2D.6 • 11:45
30 GHz Supercontinuum Generation for Astronomy with Efficient SiN Waveguides, Connor Fredrick[1,2], Andrew J. Metcalf[2,1], Daniel Hickstein[2], David R. Carlson[2], Wesley Brand[1,2], Kartik Srinivasan[3], Scott Papp[2,1], Scott A. Diddams[2,1]; [1]*Physics, Univ. of Colorado at Boulder, USA;* [2]*Time and Frequency, National Inst. of Standards and Technology, USA;* [3]*Microsystems and Nanotechnology, National Inst. of Standards and Technology, USA.* Using silicon nitride waveguides we demonstrate octave spanning spectra at a 30 GHz repetition rate with less than 20 pJ of total pulse energy at 1 um. This high efficiency supercontinuum enables broadband and robust frequency comb generation for astronomical spectrograph calibration.

Executive Ballroom 210E	Executive Ballroom 210F	Executive Ballroom 210G	Executive Ballroom 210H
CLEO: Science & Innovations	Joint	CLEO: Science & Innovations	

SF2E • Ultrafast Phenomena—Continued

SF2E.2 • 11:30
Spectral Correlations of Phase Noise in Ultrabroadband Femtosecond Lasers, Andreas Liehl[1], Philipp Sulzer[1], David Fehrenbacher[1], Denis Seletskiy[1,2], Alfred Leitenstorfer[1]; [1]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany;* [2]*Dept. of Engeneering Physics, Polytechnique Montréal, Canada.* Phase noise in mode-locked Er:fiber systems shows strong correlations emerging from broadband nonlinear-optical processes. Our fundamental insights are key to maximize the quality of passively phase-stable frequency combs and single-cycle pulse trains.

SF2E.3 • 11:45
Soliton explosions induced by soliton fusion in a mode-locked fibre laser, Heping Zeng[1], Junsong Peng[1]; [1]*East China Normal Univ., China.* We reveal that soliton fusion can induce soliton explosions in a mode-locked fibre laser, using real-time measurement techniques. Two solitons differing in their central wavelengths due to chirp explode as they approach each other.

JF2F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect II—Continued

JF2F.3 • 11:30 Invited
Deep Learning Reconstruction of Ultrashort Laser Pulses and Ptychographic Data from Ambiguous Measurements, Tom Zahavy[1]; [1]*EE, Technion, Israel.* We propose a deep learning approach to reconstruct ultrashort laser pulses and ptychographic data from optical measurements, based on optimization and calibration of ambiguities in the measurement system. We demonstrate, numerically and experimentally, superior performance and robustness to noise.

SF2G • Laser-Based Diagnostics for Material Processing—Continued

SF2G.4 • 11:30
Measurements of Optical Nonlinearities at Mid-IR Wavelengths Using a Modified Z-Scan Technique, Manuel R. Ferdinandus[1,2], Jamie J. Gengler[2], Michael Tripepi[2], Carl Liebig[2]; [1]*Air Force Inst. of Technology, USA;* [2]*Air Force Research Lab, USA.* We measure the effective optical nonlinearity of polycrystalline zinc selenide and undoped silicon at mid-IR wavelengths using a variant of Z-scan technique that employs a quadrant photodiode to simplify alignment and enhance sensitivity.

SF2G.5 • 11:45
Optical Diagnostics and Hydrophobicity of Femtosecond Laser-Modified Polymers, Deepak Kallepalli[1,2], Alan T. Godfrey[1,2], Jesse Ratté[1,2], Zygmunt Jakubek[2], Paul B. Corkum[1,2]; [1]*Univ. of Ottawa, Canada;* [2]*National Research Council, Canada.* We report optical diagnostic studies of ultrafast laser-induced changes and hydrophobicity in polyimide films when fs-pulses are focused through glass in backward incident geometry at glass-polymer interface.

SF2H • Active & Reconfigurable Devices—Continued

SF2H.3 • 11:15
Reducing Actuation Nonlinearity of MEMS Phase Shifters for Reconfigurable Photonic Circuits, Pierre Edinger[1], Carlos Errando-Herranz[1], Kristinn B. Gylfason[1]; [1]*Micro and Nanosystems, KTH Royal Inst. of Technology, Sweden.* The low power consumption of MEMS actuators enables large-scale reconfigurable photonic circuits. However, insertion loss and actuation linearity need improvement. By simulations and experiments, we analyze the dominating design parameters affecting linearity and suggest improvements.

SF2H.4 • 11:30
Reversible Switching of Optical Phase Change Materials Using Graphene Microheaters, Carlos A. Ríos Ocampo[1], Yifei Zhang[1], Tian Gu[1], Juejun Hu[1]; [1]*MIT, USA.* We demonstrate, for the first time, non-volatile tunable photonics that makes use of graphene microheaters to thermally switch large-area, low-loss phase change materials. This framework enables scalable nonvolatile integrated photonics and free-space optics applications.

SF2H.5 • 11:45
High-Q Microresonators Integrated with Microheaters on a 3C-SiC-on-Insulator Platform, XI WU[1], Tianren Fan[1], Ali Eftekhar[1], Ali Adibi[1]; [1]*Georgia Inst. of Technology, USA.* We demonstrate thermally-reconfigurable high-Q microring resonators with integrated microheaters on a 3C-SiC-on-insulator platform. A resonance shift of 30 pm/mW is achieved in 40μm-radius microrings (Q_0~88,000 at λ=1550 nm), corresponding to ~50 mW per π phase shift.

Meeting Room 211 A/B | Meeting Room 211 C/D | Meeting Room 212 A/B | Meeting Room 212 C/D

CLEO: Science & Innovations

SF2I • High Q Cavity, Resonators Application—Continued

SF2I.4 • 11:30
Waveguide-Coupled Disk Resonators on a Crack-Free Si_3N_4 Film with a Dense Stress Release Pattern, Kaiyi Wu[1], Andrew W. Poon[1]; [1]*HKUST, Hong Kong.* We deposit a crack-free 780nm-thick Si_3N_4 film on a dense stress release pattern on a 100mm silicon wafer. Our fabricated waveguide-coupled 920μm-radius Si_3N_4 disk resonator reveals a high loaded quality factor of 1.7×10^6.

SF2I.5 • 11:45
Continuous scanning of a dissipative Kerr-microresonator soliton comb by Pound-Drever-Hall locking, Naoya Kuse[1], Tomohiro Tetsumoto[1], Yi Xuan[2,3], Martin E. Fermann[1]; [1]*IMRA America Inc, USA;* [2]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [3]*Birck Nanotechnology Center, Purdue Univ., USA.* We propose and demonstrate a novel technique for continuous and autonomous scanning of a dissipative Kerr-microresonator soliton comb facilitated by Pound-Drever-Hall locking.

SF2J • Lithium Niobate & Perovskite Photonic Devices—Continued

SF2J.4 • 11:15
Integrated Electro-Optic Spectrometers on Thin-Film Lithium Niobate, Marc Reig[1], David Pohl[1], Mohammad Madi[2], Peter Brotzer[1], Fabian Kaufmann[1], Anton Sergeyev[1], Urs Meier[2], Edoardo Alberti[2], Rachel Grange[1]; [1]*ETH Zürich, Switzerland;* [2]*Micos Engineering GmbH, Switzerland.* We demonstrate the concept of an integrated waveguide Fourier transform spectrometer on a thin-film lithium niobate platform. The material's electro-optic properties enable on-chip phase-modulations to overcome undersampling restrictions by shifting the evanescently probed standing wave.

SF2J.5 • 11:30
Self-starting lithium niobate soliton microcombs, Yang He[1], Qi-Fan Yang[2], Jingwei Ling[1], Rui Luo[1], Hanxiao Liang[1], Mingxiao Li[1], Boqiang Shen[2], Heming Wang[2], Kerry J. Vahala[2], Qiang Lin[1]; [1]*Univ. of Rochester, USA;* [2]*California Inst. of Technology, USA.* We report soliton generation in a high-Q lithium niobate resonator. The photo-refractive effect enables self-starting mode locking and is able to produce stable single solitons on demand that feature reversible switching between soliton states.

CLEO: Applications & Technology

AF2K • Spectrometers & Wavelength Metrology—Continued

AF2K.4 • 11:15
Dual Comb Assisted Spectrum-to-Time Mapping for Rapid Wavelength-encoded Tomography, Yuhua Duan[1], Lei Zhang[1], Xin Dong[1], Xi Zhou[1], Chi Zhang[1], Xinliang Zhang[1]; [1]*WNLO, China.* Leveraging a stimulated Brillouin scattering filter and the Vernier effect between two optical frequency combs, the wavelength-encoded depth information is time mapped and detected with low bandwidth, with both imaging range and imaging speed enhanced.

AF2K.5 • 11:30
Scalable Bandwidth All-fiber Spectrometer using Spatial Multiplexing, Ziyi Meng[1], Zhenming Yu[1], Jianqiang Li[1], Chunjing Yin[1], Tian Zhang[1], Ming Tang[2], Weijun Tong[3], Kun Xu[1]; [1]*Beijing Univ of Posts & Telecom, China;* [2]*Huazhong Univ. of Science & Technology, China;* [3]*Yangtze Optical Fibre and Cable Limited Company, China.* We propose and experimentally demonstrate a large bandwidth and high-resolution all-fiber speckle-based spectrometer using spatial multiplexing, which is constructed by integrating a multicore fiber (MCF) with a multimode fiber (MMF).

AF2K.6 • 11:45
Super-resolution in a compact Fourier Transform InfraRed (FT-IR) spectrometer, Erga Lifshitz[1], Uri Arieli[1], Shahar Katz[1], Assaf Levanon[1], Michael Mrejen[1], Haim Suchowski[1]; [1]*Tel Aviv Univ., Israel.* We introduce a novel method to achieve a compact, high resolution FT-IR spectrometer. By simulation and experimental results we demonstrate that effectively increasing the size of the FT-IR by stitching different interferograms yields spectral super-resolution.

CLEO: Science & Innovations

SF2L • MID-IR Fiber Sources—Continued

SF2L.3 • 11:15
High Power Dy-doped Fluoride Fiber Laser Operating Beyond 3 μm, Vincent Fortin[1], Frédéric Jobin[1], Maxence Larose[1], Martin Bernier[1], Réal Vallée[1]; [1]*Centre d'optique, photonique et laser (COPL), Université Laval, Canada.* We demonstrate an entirely monolithic dysprosium-doped fiber laser system producing a record output power of 10 W at 3.24 μm based on in-band pumping at 2.8 μm.

SF2L.4 • 11:30 Invited
Breaking Through the Wavelength Barrier: State-of-play on Rare-earth Ion Mid-infrared Fiber Lasers at 4-9 mm, Angela Seddon[1], Zhuoqi Tang[1], David Furniss[1], Emma Barney[1], Lukasz Sojka[2], Trevor Benson[1], Slawomir Sujecki[2,1]; [1]*Univ. of Nottingham, UK;* [2]*Wroclaw Univ. of Technology, Poland.* Fiber lasing at 3.9 mm was reported in 1995, but has not yet been demonstrated at 4 mm or longer wavelengths. Rare-earth-ion behavior in low optical-phonon energy hosts is appraised and host confounding issues explored.

Joint

JF2M • Professional Development Session II—Continued

CLEO: Science & Innovations

SF2N • RF Photonics—Continued

SF2N.4 • 11:15
Tunable Photonic RF Bandpass Filters based on an 80 Channel Kerr Micro-Comb Source, Mengxi Tan[1], Xingyuan Xu[1], Jiayang Wu[1], Thach Nguyen[2], Sai Chu[3], Brent Little[4], Roberto Morandotti[5], Arnan Mitchell[2], David Moss[1]; [1]*Swinburne Univ. of Technology, Australia;* [2]*RMIT Univ., Australia;* [3]*City Univ. of Hong Kong, China;* [4]*Chinese Academy of Science, China;* [5]*INSR-Énergie, Matériaux et Télécommunications, Canada.* We demonstrate a tunable photonic RF bandpass filter based on a Kerr micro-comb source providing 80 taps in the C-band. We achieve a widely tunable centre frequency (0.05FSR_{RF} ~ 0.40FSR_{RF}) and 3-dB bandwidth (0.5 ~ 4.6 GHz).

SF2N.5 • 11:30
Photonic-chip based RF signal detection system with improved bandwidth and sensitivity, zihang zhu[1,2], Moritz Merklein[1,3], Duk-yong Choi[4], Khu Vu[4], Pan Ma[4], Stephen Madden[4], Benjamin J. Eggleton[5,3]; [1]*Inst. of Photonics and Optical Science (IPOS), School of Physics, The Univ. of Sydney, Australia;* [2]*The Faculty of Automation & Information Engineering, Xi'an Univ. of Technology, China;* [3]*Sydney Nano Inst. (Sydney Nano), The Univ. of Sydney, Australia;* [4]*Laser Physics Centre, Australian National Univ., Australia.* We demonstrate on-chip RF signal detection with high sensitivity and broad bandwidth using a Brillouin opto-electronic oscillator. RF signals with power levels as low as -65dBm and a frequency range of 1.5-40 GHz are detected.

SF2N.6 • 11:45
A Photodetector-Driven Coherent RF Array with Wide Tuning Range, Behrooz Abiri[2], Craig Ives[1], Ali Hajimiri[1]; [1]*California Inst. of Technology, USA;* [2]*Auspion Inc., USA.* A sixteen-element coherent array of wideband spiral antennas driven by photodetectors is presented. The array radiates between 21 and 65 GHz, with -45 dBm of coupled power at 42 GHz.

SF2O • Optoelectronic Materials—Continued

SF2O.4 • 11:15
UV Laser Resist-Mask Writing for Low-Cost Prototyping of Integrated Optical Devices, Dawson Bonneville[1], Manuel Arturo Méndez-Rosales[1], Henry Frankis[1], Jonathan D. B. Bradley[1]; [1]*Engineering Physics, Canada.* We report on UV-laser photoresist-mask writing as a tool for fabricating integrated optical waveguides. We investigate feature width and roughness under different write settings and apply the technique to realize integrated Si_3N_4 waveguides and devices.

SF2O.5 • 11:30
Optical and Electrical Properties of Phase Change Materials for High-Speed Optoelectronics, Joshua Burrow[1], Pengfei Guo[1], Gary A. Sevison[1,2], Heungdong Kwon[3], Christopher Perez[3], Mehdi Asheghi[3], Joshua R. Hendrickson[2], Andrew Sarangan[1], Kenneth E. Goodson[3], Imad Agha[4,1]; [1]*Electro-Optics, Univ. of Dayton, USA;* [2]*Sensors Directorate, Air Force Research Lab, USA;* [3]*Mechanical Engineering, Stanford Univ., USA;* [4]*Physics, Univ. of Dayton, USA.* By doping $Ge_2Sb_2Te_5$ phase change material with tungsten, we produce material with improved electrical properties while simultaneously maintaining the optical contrast necessary for light modulation and switching.

SF2O.6 • 11:45
Optically Re-Writable Dynamic Resistors for Optoelectronic and Reconfigurable Computing Applications, Gary A. Sevison[1], Edward C. Ruff[1], Joshua Burrow[1], Pengfei Guo[1], Joshua R. Hendrickson[2], Andrew Sarangan[1], Imad Agha[1,3]; [1]*Electro-Optics and Photonics, Univ. of Dayton, USA;* [2]*Sensors Directorate, Wright-Patterson Air Force Research Labs, USA;* [3]*Physics, Univ. of Dayton, USA.* By employing the phase transition properties of germanium-antimony-telluride, we demonstrate optically rewritable electronic resistors, which can be used to dynamically reconfigure hardwired electronic circuits for optoelectronic and computing applications.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FF2A • Photonic Crystals & Periodic Nano Optics—Continued

FF2A.7 • 12:00
Optical Pressure on a Structured Surface, Li-Fan Yang[1], Anurup Datta[1], Yu-Chun Hsueh[1], Xianfan Xu[1], Kevin J. Webb[1]; [1]*Purdue Univ., USA.* We experimentally demonstrate for the first time that the optical pressure on a nanostructured surface can exceed that on a planar mirror by virtue of exploiting the third dimension and an asymmetric plasmon wave resonance.

FF2A.8 • 12:15
Dynamic Control of Plasmonic Beams, Dror weisman[1], Ady Arie[1]; [1]*Tel Aviv Univ., Israel.* We actively control the propagation of plasmonic beams using the thermo-optic effect, by selectively inducing electrical current through specific areas. We demonstrate a dynamic mode converter and a tunable plasmonic lens.

FF2B • Linear/Non-Linear Metasurfaces—Continued

FF2B.7 • 12:00
Helicity-Multiplexed Hologram via All-dielectric Metasurface in the Visible Domain, Muhammad Afnan Ansari[1,2], Muhammad Qasim Mehmood[1], Muhammad Hamza Waseem[1,3], Inki Kim[4], Nasir Mahmood[5,6], Tauseef Tauqeer[1], Selcuk Yerci[2,7], Junsuk Rho[4]; [1]*Information Technology Univ. of the Punjab, Lahore, Pakistan, Pakistan;* [2]*Dept. of Electrical and Electronics Engineering, Middle East Technical Univ., 06800 Çankaya/Ankara, Turkey., Turkey;* [3]*Dept. of Electrical Engineering, Univ. of Engineering and Technology, Lahore 54000, Pakistan, Pakistan;* [4]*Dept. of Mechanical Engineering, Pohang Univ. of Science and Technology (POSTECH), Pohang 37673, South Korea, South Korea (the Republic of);* [5]*National Univ. of Sciences and Technology (NUST), Islamabad, Pakistan, Pakistan;* [6]*Enginering Dept., Univ. of Lahore, Lahore, Pakistan, Pakistan;* [7]*Dept. of Micro and Nanotechnology, Middle East Technical Univ., 06800 Çankaya/Ankara, Turkey, Turkey.* A transmission type helicity-multiplexed metasurface hologram is demonstrated at wavelength of 633 nm using low loss hydrogenated amorphous silicon to achieve the pragmatic features of metasurfaces in the integrated photonic circuits.

FF2B.8 • 12:15
Multi-Element Meta-lens Systems for Imaging, Sajan Shrestha[1], Adam C. Overvig[1], Nanfang Yu[1]; [1]*Columbia Univ., USA.* We experimentally demonstrated chromatic and monochromatic aberration correction in a meta-lens triplet system up to a wavelength range of ~300 nm in the near-infrared by utilizing dispersion engineering of meta-atoms.

FF2C • Attosecond Pulse Generation & Characterization—Continued

FF2C.6 • 12:00
Helicity in a Twist: Attosecond, Extreme Ultraviolet Vortex Beams with Designer Spin and Orbital Angular Momenta, Kevin Dorney[1], Laura Rego[2], Nathan Brooks[1], Julio San Román[2], Chen-Ting Liao[1], Jennifer Ellis[1], Dmitriy Zusin[1], Christian Gentry[1], Quynh L. Nguyen[1], Justin Shaw[3], Antonio Picon[4], Luis Plaja[2], Henry Kapteyn[1], Margaret Murnane[1], Carlos Hernandez-Garcia[2]; [1]*Physics, JILA - Univ. of Colorado Boulder, USA;* [2]*Departamento de Física Aplicada, Universidad de Salamanca, Spain;* [3]*Quantum Electromagnetics Division, National Inst. of Standards and Technology, USA;* [4]*Departamento de Quimica, Universidad Autonoma de Madrid, Spain.* High-harmonics—and attosecond pulses—with controllable spin and orbital angular momenta (SAM and OAM) are generated for the first time. The coupled SAM-OAM conservation laws enable exquisite control over the polarization of attosecond pulse trains.

FF2C.7 • 12:15
An Extreme Ultraviolet Spin Grating for Spatially Resolved, Hyperspectral Magnetic Dichroism Spectroscopies, Nathan J. Brooks[4], Kevin M. Dorney[4], Jennifer L. Ellis[4,3], Daniel Hickstein[4,3], Quynh L. Nguyen[4], Christian Gentry[4], Carlos Hernandez-Garcia[1], Dmitriy Zusin[4], Justin Shaw[5], Matthijs Jansen[2], Stefan Witte[2], Henry Kapteyn[4], Margaret M. Murnane[4]; [1]*Departamento de Física Aplicada, Universidad de Salamanca, Spain;* [2]*Advanced Research Center for Nanolithography (ARCNL), Netherlands;* [3]*Time and Frequency Division, National Inst. of Standards and Technology, USA;* [4]*Dept. of Physics, JILA, USA;* [5]*Quantum Electromagnetics Division, National Inst. of Standards and Technology, USA.* Phase-locked, orthogonally polarized high-harmonic sources are employed to produce an extreme ultraviolet optical spin grating. This spin grating is ideal for hyperspectral, dichroic imaging allowing, for example, spatially resolved dichroism measurements at magnetic M edges.

FF2D • Frequency Comb & Supercontinuum Generation—Continued

FF2D.7 • 12:00
Supercontinuum Generation in Titanium Dioxide Waveguides, Kamal Hammani[1], Laurent Markey[1], Manon Lamy[1], Bertrand Kibler[1], Juan Arocas[1], Julien Fatome[1], Alain Dereux[1], Jean-Claude Weeber[1], Christophe Finot[1]; [1]*Laboratoire Interdisciplinaire Carnot de Bourgogne, Université Bourgogne Franche-Comté, France.* We report the design and fabrication of titanium dioxide optical waveguides optimized for supercontinuum generation in the mid-infrared. A spectrum spanning from the visible up to 2 μm is experimentally demonstrated.

FF2D.8 • 12:15
Tailoring the Dispersion of a Hybrid Chalcogenide/Silicon-Germanium Waveguide for Mid-Infrared Supercontinuum Generation, Alberto Della Torre[1], Milan Sinobad[1,4], Barry Luther-Davis[2], Pan Ma[2], Stephen Madden[2], Sukanta Debbarma[2], Khu Vu[2], David Moss[3], Arnan Mitchell[4], Jean-Michel Hartmann[5], Jean-Marc Fedeli[5], Christelle Monat[1], Christian Grillet[1]; [1]*Institut des Nanotechnologies de Lyon, France;* [2]*Australian National Univ., Australia;* [3]*Swinburne Univ. of Technology, Australia;* [4]*RMIT Univ., Australia;* [5]*CEA-Leti, France.* We report mid-infrared supercontinuum generation in a silicon germanium-on-silicon waveguide. We show that the dispersion properties of the waveguide can be precisely tuned by controlling the thickness of a chalcogenide cladding layer.

12:30–14:00 Lunch Break (On your Own)

Executive Ballroom 210E

CLEO: Science & Innovations

SF2E • Ultrafast Phenomena—Continued

SF2E.4 • 12:00 Invited
Attosecond Tracking of Electron Dynamics in Large Molecules, Francesca Calegari[1,2]; [1]*Deutsches Elektronen Synchrotron, Germany;* [2]*Physics, Hamburg Univeristy, Germany.* A new attosecond beamline combining 200-as XUV pulses with sub-2 fs UV pulses is presented. The application of attosecond technology for the investigation of electronic processes in bio-relevant molecules is discussed.

Executive Ballroom 210F

Joint

JF2F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect II—Continued

JF2F.4 • 12:00
Training Deep Neural Networks for the Inverse Design of Nanophotonic Structures, Dianjing Liu[1], Yixuan Tan[1], Erfan Khoram[1], Zongfu Yu[1]; [1]*Univ. of Wisconsin - Madison, USA.* We demonstrate a tandem neural network architecture that tolerates inconsistent training instances in inverse design of nanophotonic devices. It provides a way to train large neural networks for the inverse design of complex photonic structures.

JF2F.5 • 12:15
Large-Scale Optical Neural-Network Accelerators based on Coherent Detection, Ryan Hamerly[1], Alex Sludds[1], Liane Bernstein[1], Marin Soljacic[1], Dirk R. Englund[1]; [1]*MIT, USA.* We present a coherent optical neural-network accelerator based on homodyne detection that is scalable to large (N > 1000) networks, and analyze the fundamental quantum limits to its energy efficiency.

Executive Ballroom 210G

CLEO: Science & Innovations

SF2G • Laser-Based Diagnostics for Material Processing—Continued

SF2G.6 • 12:00
Atom Probe Tomography with Extreme-Ultraviolet Light, Luis Miaja Avila[1], Ann Chiaramonti[1], Paul Blanchard[1], Norman Sanford[1], David Diercks[2], Brian Gorman[2]; [1]*NIST, USA;* [2]*Colorado School of Mines, USA.* We have adapted an atom probe tomograph (APT) with an extreme ultraviolet (EUV) source. The EUV photon energies open a direct photoionization pathway unavailable in conventional near-UV APT.

SF2G.7 • 12:15
Towards Stark Coefficient Determination in Laser-produced Uranium Plasma, Milos Burger[1], Patrick J. Skrodzki[1], Igor Jovanovic[1], Mark C. Phillips[2], Sivanandan S. Harilal[2]; [1]*Univ. of Michigan, USA;* [2]*Pacific Northwest National Lab, USA.* We performed spatiotemporal diagnostics of excitation temperature and electron density of laser-induced uranium plasma. The results are prerequisite for Stark broadening and shift coefficients determination, required for accurate modeling of uranium emission spectra.

Executive Ballroom 210H

SF2H • Active & Reconfigurable Devices—Continued

SF2H.6 • 12:00
A sub-10 μK, dual-mode temperature stabilized microresonator, Jinkang Lim[1,2], Anatoliy Savchenkov[3], Yoon-Soo Jang[1], Andrey B. Matsko[3], Chee Wei Wong[1]; [1]*Univ. of California Los Angeles, USA;* [2]*Photonics Solutions, LGS innovations LLC, USA;* [3]*OEwaves Inc., USA.* We show a resonator long-term temperature stability of 8.53 μK after stabilization and unveil various sources that hinder the stability from reaching sub-μK in the current system.

SF2H.7 • 12:15
Design of a tapered slot waveguide dielectric laser accelerator for sub-relativistic electrons, Zhexin Zhao[1], Tyler Hughes[1], Si Tan[1], Huiyang Deng[1], Neil Sapra[1], Joel England[2], Jelena Vuckovic[1], James Harris[1], Robert Byer[1], Shanhui Fan[1]; [1]*Stanford Univ., USA;* [2]*SLAC National Accelerator Lab, USA.* We design and analyze a tapered slot waveguide structure for sub-relativistic electron acceleration. The tapering scheme can be designed, through the eikonal approximation, to achieve phase synchronization with the accelerated electrons.

12:30–14:00 Lunch Break (On your Own)

Meeting Room 211 A/B | Meeting Room 211 C/D — CLEO: Science & Innovations

SF2I • High Q Cavity, Resonators Application—Continued

SF2I.6 • 12:00
High-Q Resonators on Single Crystal Aluminum Nitride Grown by Molecular Beam Epitaxy, Yi Sun[1], David Laleyan[1], Eric Reid[1], Ping Wang[1], Xianhe Liu[1], Ayush Pandey[1], Mohammad Soltani[2], Zetian Mi[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Michigan , USA;* [2]*Raytheon BBN Technologies, USA.* We report the demonstration of high-Q (> 70,000) microring resonators at 770 nm wavelength using single crystal aluminum nitride (AlN) grown by molecular-beam-epitaxy (MBE) which is a crucial growth technique enabling electronic/photonic integration with III-Nitrides.

SF2I.7 • 12:15
Control of Kerr-microresonator optical frequency comb by a dual-parallel Mach-Zehnder interferometer, Naoya Kuse[1], Travis C. Briles[2,3], Scott B. Papp[2,3], Martin E. Fermann[1]; [1]*IMRA America Inc, USA;* [2]*Time and Frequency Division, National Inst. of Standards and Technology, USA;* [3]*Dept. of Physics, Univ. of Colorado, USA.* We propose and demonstrate a simple technique to generate a stable dissipative Kerr comb and to control f_{rep} and f_{ceo} of the comb, in which only one device, i.e. dual-parallel Mach-Zehnder interferometer is used.

SF2J • Lithium Niobate & Perovskite Photonic Devices—Continued

SF2J.6 • 12:00
High-quality Lithium Niobate Optomechanical Crystal, Wentao Jiang[1], Rishi Patel[1], Felix M. Mayor[1], Timothy McKenna[1], Patricio Arrangoiz-Arriola[1], Christopher J. Sarabalis[1], Raphaël Van Laer[1], Amir Safavi-Naeini[1]; [1]*Stanford Univ., USA.* We demonstrate 1D lithium niobate optomechanical crystal with 1550 nm optical mode with quality factor 300,000 and 1.9 GHz mechanical mode with quality factor 37,000 at 4 Kelvin. The optomechanical coupling rate is measured to be g0/2pi = 120 kHz.

SF2J.7 • 12:15
Phase-Shifted Bragg Grating Resonators in Thin-Film Lithium Niobate Waveguides, Mohammad Amin Baghban[1], Katia Gallo[1]; [1]*KTH Royal Inst. of Technology, Sweden.* We demonstrate narrowband integrated filters with 0.23 mm-long phase-shifted Bragg gratings in corrugated single-mode thin-film $LiNbO_3$ photonic wires, achieving quality factors of 1.24×10^4 and extinction ratios up to 24 dB at telecom wavelengths.

Meeting Room 212 A/B — CLEO: Applications & Technology

AF2K • Spectrometers & Wavelength Metrology—Continued

AF2K.7 • 12:00
Ultranarrow-band metagrating absorbers for sensing and modulation, Aosong Feng[1], Zejie Yu[1], Xiankai Sun[1]; [1]*Electronics Engineering, The Chinese Univ. of Hong Kong, Hong Kong.* An asymmetric metagrating structure with an ultranarrow bandwidth of 0.28 nm at 1.55 μm is proposed. Sensing with figure-of-merit of 1333.33 RIU^{-1} and electro-optic modulation with dynamic range of 15.52 dB are numerically demonstrated.

AF2K.8 • 12:15
Spherical mirrors based compact multipass cell with dense astigmatic-like spot pattern, Arkadiusz Hudzikowski[1], Aleksander Gluszek[1], Karol Krzempek[1], Jaroslaw Sotor[1]; [1]*Wroclaw Univ. of Science and Techn., Poland.* A multipass trace gas cell with 24 m optical path length and 80 cc volume was developed and built. A direct ray tracing and genetic algorithm was used to determine optimal mirror arrangement.

Meeting Room 212 C/D — CLEO: Science & Innovations

SF2L • MID-IR Fiber Sources—Continued

SF2L.5 • 12:00
High Energy Er:ZBLAN LMA Fiber Amplifier Producing ~200μJ and ~10ns Pulses at 2.72μm, Weizhi Du[1], Xuan Xiao[2], Yifan Cui[1], Mingshu Chen[1], Igor Jovanovic[2], Almantas Galvanauskas[1]; [1]*Center for Ultrafast Optical Science, Univ. of Michigan, USA;* [2]*Nuclear Engineering and Radiological Sciences, Univ. of Michigan, USA.* Pulsed amplification at 2.7μm in Er:ZBLAN LMA fibers was explored demonstrating up to 194μJ in 9.7ns, the highest short-pulse energies from these mid-IR fibers. We also measured fiber damage threshold and 650μJ of stored energy.

SF2L.6 • 12:15
Ultrafast Thulium-Doped Fiber Laser System at 1.8 μm for Multiphoton Microscopy, Yutaka Nomura[1,2], Takao Fuji[1]; [1]*Inst. for Molecular Science, Japan;* [2]*JST, PRESTO, Japan.* An ultrafast laser system at 1.8 μm is developed based on thulium-doped ZBLAN fibers. The generated pulses are used in a three-photon microscope to observe the images of fluorescent beads for ~600 nm.

12:30–14:00 Lunch Break (On your Own)

Marriott
Salon I & II

Marriott
Salon III

Marriott
Salon IV

Joint

CLEO: Science & Innovations

JF2M • Professional Development Session II—Continued

SF2N • RF Photonics—Continued

SF2N.7 • 12:00
Brillouin-loss Enabled Noise Figure Improvement for Chip-based Tunable Microwave Photonic Filters, Yiwei Xie[1], Amol Choudhary[1], Yang Liu[1], David Marpaung[2], Khu Vu[3], Pan Ma[3], Duk-yong Choi[3], Stephen Madden[3], Benjamin J. Eggleton[1]; [1]*Univ. of Sydney, Australia;* [2]*Univ. of Twente, Netherlands;* [3]*Australian National Univ., Australia.* We compare the noise figure (NF) of chip-based tunable microwave photonic band-pass filters using stimulated Brillouin scattering (SBS) gain and loss responses, respectively. The filter using SBS loss scheme exhibits 10-dB lower NF than that using SBS gain scheme.

SF2N.8 • 12:15
Rapid Wideband RF Subsampling and Disambiguation Using Dual Combs, Mohammed S. Al Alshaykh[1,2], Daniel E. Leaird[1,2], Jason D. McKinney[3], Andrew M. Weiner[1,2]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA;* [3]*U.S. Naval Research Lab, USA.* Using two electro-optic combs with an offset in the repetition rate, we disambiguate RF signals over 20 Nyquist bands. The setup doesn't require a pulse compression stage and can be readily integrated using existing technology.

SF2O • Optoelectronic Materials—Continued

SF2O.7 • 12:00
High-Performance Mid-Infrared Crystalline Bragg Mirrors at 4.5 µm, Georg Winkler[1], Lukas Perner[1], Gar-Wing Truong[2], Dominic Bachmann[3], Aline S. Mayer[1], Jakob Fellinger[1], Tobias Zederbauer[3], David Follman[2], Christoph Deutsch[3], Garrett D. Cole[2,3], Oliver H. Heckl[1]; [1]*Christian Doppler Lab for Mid-IR Spectroscopy and Semiconductor Optics, Faculty Center for Nano Structure Research, Faculty of Physics, Univ. of Vienna, Austria;* [2]*Crystalline Mirror Solutions LLC, USA;* [3]*Crystalline Mirror Solutions GmbH, Austria.* We present state-of-the-art mid-IR high-reflectivity low-loss mirrors at 4.55 µm based on substrate-transferred crystalline coatings. Transmission losses of 150 ppm and excess losses of <50 ppm are demonstrated via cavity-ringdown and direct transmission measurements.

SF2O.8 • 12:15
Nd:Y_2O_3 Transparent Ceramics: Fabrication and Laser Performance, Danlei Yin[1], Jun Wang[1], Zhili Dong[1], Martin Richardson[2], Dingyuan Tang[1]; [1]*Nanyang Technological Univ., Singapore;* [2]*Univ. of Central Florida, USA.* 0.6 at% Nd:Y_2O_3 transparent ceramics with high optical quality were fabricated by vacuum sintering plus hot isostatic pressing. High efficiency CW laser operation at 1.08 and 1.36 µm were demonstrated.

12:30–14:00 Lunch Break (On your Own)

Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D

CLEO: QELS-Fundamental Science

14:00–16:00
FF3A • Single-Photon Collection & Characterization
Presider: Marcelo Davanco; NIST, USA

FF3A.1 • 14:00
Inverse Designed Diamond Nanophotonics, Constantin Dory[1], Dries Vercruysse[1], Kiyoul Yang[1], Neil Sapra[1], Alison E. Rugar[1], Shuo Sun[1], Daniil Lukin[1], Alexander Y. Piggott[1], Linda Jingyuan Zhang[1], Marina Radulaski[1], Konstantinos Lagoudakis[1], Logan Su[1], Jelena Vuckovic[1]; [1]*Stanford Univ., USA.* Combining inverse design optimization methods and quasi-isotropic etching techniques, we develop compact, flexible and efficient photonic components in diamond for applications in quantum technologies.

FF3A.2 • 14:15
Waveguide-coupled Localized Excitons From a WSe$_{2}$ monolayer on a Silicon Nitride Photonic Platform, Frédéric Peyskens[1,2], Chitraleema Chakraborty[1], Muhammad Muneeb[2], Dries Van Thourhout[2], Dirk R. Englund[1]; [1]*MIT, USA;* [2]*Ghent Univ., Belgium.* We demonstrate the coupling of localized excitons from a WSe$_{2}$ monolayer into a silicon nitride waveguide by measuring the waveguide-coupled fluorescence, paving the way towards scalable fabrication of on-chip single photon sources.

FF3A.3 • 14:30
Deterministically coupled quantum emitters in a hexagonal Boron Nitride hybrid microcavity system, Nicholas Proscia[1], Harishankar Jayakumar[1], Zav Shotan[1], Gabriel Lopez-Morales[1], Xiaochen Ge[2], Weidong Zhou[2], Carlos Meriles[1], Vinod Menon[1]; [1]*CUNY City College of New York, USA;* [2]*Univ. of Texas at Arlington, USA.* We demonstrate a hybrid microphotonic device by integrating a thin film of hexagonal Boron Nitride containing quantum emitters with Si_3N_4 microdisk resonators. We deterministicallyactive these emitters via strain within a microdisk's evanescent field.

14:00–16:00
FF3B • Disordered Media
Presider: To Be Announced

FF3B.1 • 14:00
Light Propagation in Temporally Disordered Media, Yonatan Sharabi[1], Eran Lustig[1], Mordechai Segev[1]; [1]*Technion, Israel.* We study light propagation in a medium with a homogeneous refractive index that varies randomly in time. We find that, in stark contrast to spatial disorder, temporal disorder causes exponential increase of the light intensity.

FF3B.2 • 14:15
Spatio-temporal response of random media beyond ensemble averages, Ruitao Wu[1], Aristide Dogariu[1]; [1]*CREOL, USA.* We demonstrate measurements of full spatio-temporal correlations between photon path lengths in highly scattering media. The dependence on the structural characteristics of the medium and the connection to memory-like phenomena are discussed.

FF3B.3 • 14:30
Memory effect of transmission eigenchannels in random media, Hasan Yilmaz[1], Chia Wei Hsu[1], Alexey Yamilov[2], Hui Cao[1]; [1]*Yale Univ., USA;* [2]*Dept. of physics, Missouri Univ. of Science & Technology, USA.* We have experimentally and numerically studied the angular memory effect of transmission eigenchannels in random media. High-transmission channels have a larger range of memory effect than any input wavefront, thus are robust against sample tilt.

14:00–16:00
FF3C • Attosecond Dynamic Imaging
Presider: Shambhu Ghimire; SLAC National Accelerator Laboratory, USA

FF3C.1 • 14:00 Invited
Probing Electronic Binding Potentials with Attosecond Photoelectron Wavepackets, Robert R. Jones[1], Dietrich Kiesewetter[2], Antoine Camper[2], Stephen B. Schoun[2], Pierre Agostini[2], Louis F. DiMauro[2]; [1]*Univ. of Virginia, USA;* [2]*The Ohio State Univ., USA.* We show that energy transfer between a mid-infrared dressing field and low-energy attosecond photoelectron wavepackets provides direct coarse-grained information on the effective binding potential experienced by the electrons during the first femtosecond following their ionization.

FF3C.2 • 14:30
Subcycle dynamics of ionization revealed via polarization of lowest harmonics, Ihar Babushkin[2,1], Alvaro G. Galan[1], Virgilijus Vaičaitis[3], Anton H. Husakou[1], Felipe Morales[1], Ayhan Demircan[2,4], José Andrade[2,4], Uwe Morgner[2,4], Misha Ivanov[1]; [1]*Max-Born Inst., Germany;* [2]*Inst. of Quantum Optics, Univ. of Hannover, Germany;* [3]*Laser Research Center, Vilnius Univ., Lithuania;* [4]*Hannover Centre for optical Technologies, Germany.* We show that by looking at the polarization of lowest (0th and 3d) harmonics of the atomic response it is possible to determine details of attosecond-scale ionization dynamics including ionization time and its temporal asymmetry.

14:00–16:00
FF3D • Nonlinear & Quantum Effects
Presider: To Be Announced

FF3D.1 • 14:00
Measurement of excitation coherence lengths using multi-spatial-mode four-wave mixing, Torben L. Purz[1,2], Eric Martin[1], Zhaorong Wang[1], Hui Deng[1], Steven T. Cundiff[1]; [1]*Dept. of Physics, Univ. of Michigan , USA;* [2]*Dept. of Physics, Univ. of Goettingen, Germany.* We develop a multi-spatial-mode four-wave mixing (FWM) experiment to determine the coherence length of quasiparticles. We present evidence for nonlocal effects in a microcavity polariton system that affect nonlinear optical processes such as FWM.

FF3D.2 • 14:15
Nonlinear Plasmonic Enhancement with Graphene Heterostructures, Irati Alonso Calafell[1], Lee A. Rozema[1], David Alcaraz Iranzo[2], Alessandro Trenti[1], Hlib Bieliaiev[1], Frank H. Koppens[2], Philip Walther[1]; [1]*Univ. of Vienna, Austria, Austria;* [2]*ICFO, Spain.* Nonlinear nanoplasmonics provides precise control and manipulation of light. Graphene sustains electrically tunable and long-lived plasmons. By combining these platforms, we observe a 10^2 enhancement in the third-harmonic generation in graphene heterostructures.

FF3D.3 • 14:30
Spectral and angular dependence of the giant nonlinear refraction of Indium Tin Oxide excited at epsilon-near-zero, Sepehr Benis[1], Natalia Munera[1], David J. Hagan[1], Eric W. Van Stryland[1]; [1]*Univ. of Central Florida, CREOL, USA.* We report beam-deflection measurements of indium tin oxide excited around epsilon-near-zero (ENZ), but probed far from ENZ. Nonlinear refraction is very large even far from ENZ and enhanced as the excitation is tuned through ENZ.

Executive Ballroom 210E

CLEO: Science & Innovations

14:00–16:00
SF3E • Ultrafast Oscillators
Presider: Simon Duval; Femtum, Canada

SF3E.1 • 14:00
20 MW Mamyshev Oscillator featuring LMA-PCF, Wu Liu[1], Ruoyu Liao[1], Jun Zhao[1], Jiahua Cui[1], Youjian Song[1], Chingyue Wang[1], Ming-lie Hu[1]; [1]*Tianjin Univ., China.* We demonstrate a Mamyshev oscillator featuring large-mode-area photonic crystal fibers (LMA-PCF). The laser generates over 1 μJ pulses which can be dechirped down to 41 fs, leading to pulse peak powers of ~20 MW.

SF3E.2 • 14:15
Fiber oscillator mode-locked using a novel scheme for Nonlinear Polarization Evolution in Polarization Maintaining fibers, Jan Szczepanek[1], Tomasz Kardas[2], Bernard Piechal[3], Yuriy Stepanenko[3]; [1]*Inst. of Experimental Physics, Faculty of Physics, Univ. of Warsaw, Poland;* [2]*Fluence sp. z o. o., Poland;* [3]*Inst. of Physical Chemistry PAS, Poland.* We present an environmentally stable ultrafast oscillator employing a novel implementation of a multi-segment All Polarization-Maintaining-Fiber Nonlinear Polarization Evolution reflective artificial Saturable Absorber. Oscillator emits 1 nJ pulses with duration of 230 fs after compression.

SF3E.3 • 14:30
Power Scaling of Ultrafast Laser Oscillators: 350-W Output Power Sub-ps SESAM-Modelocked Thin-Disk Laser, Francesco Saltarelli[1], Ivan J. Graumann[1], Lang Lukas[1], Dominik Bauer[2], Christopher Phillips[1], Ursula Keller[1]; [1]*ETH Zurich, Switzerland;* [2]*TRUMPF Laser GmbH, Germany.* Combining vacuum operation, large pump spot, and multiple passes on the gain medium, we designed a high-power thin-disk oscillator with a record 350-W average power, 40-μJ pulses. We expect 500-W-level modelocking in the near future.

Executive Ballroom 210F

Joint

14:00–16:00
JF3F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect III

JF3F.1 • 14:30 Invited
Object Recognition with Optical Coherence, Ken Xingze Wang[1]; [1]*Huazhong Univ. of Science and Technology, China.* Computer vision systems could be improved by using wave optics instead of geometrical optics. We show that some object recognition tasks are made possible by using optical coherence.

Executive Ballroom 210G

CLEO: Science & Innovations

14:00–16:00
SF3G • Laser-Based 2D/3D Micro- & Nano-fabrication
Presider: Takashige Omats; Chiba University, Japan

SF3G.1 • 14:00
Er and Yb femtosecond laser-induced melting and shaping of indium nanostructures on silicon wafers , Ali Azarm[1], Nasser Peyghambarian[1], Farhad Akhoundi[1]; [1]*Univ. of Arizona, USA.* We use erbium and ytterbium femtosecond lasers to melt and shape semi-spherical nanostructure by high spatial frequency laser induced periodic surface structures into linear microstructures of 2 μm long in the direction of laser polarization.

SF3G.2 • 14:15
Femtosecond-Laser-Induced Blisters in Polymer Thin Films and Application as Microlenses, Alan T. Godfrey[1,2], L.N. Deepak Kallepalli[1,2], Jesse Ratté[1,2], Paul B. Corkum[1,2]; [1]*uOttawa, Canada;* [2]*National Research Council of Canada, Canada.* We present the phenomenology of blister formation by nonlinear absorption of femtosecond pulses in polyimide films, characterized by atomic force microscopy. We demonstrate a novel implementation of blisters as microlenses.

SF3G.3 • 14:30
Micron-scale 'ink-jet' created by optical vortex ablation, Ryosuke Nakamura[1], Muneaki Iwata[2], Akihiro Kaneko[2], Kohei Toyoda[1,3], Katsuhiko Miyamoto[1,3], Takashige Omatsu[1,3]; [1]*Chiba Univ., Japan;* [2]*RICOH CT&P Division, Japan;* [3]*MCRC Chiba Univ., Japan.* We have demonstrated the creation of a micron-scale 'ink-jet' by employing optical vortex laser ablation. The OAM then provides a spin of the melted ink, thereby stabilizing the formation of the 'ink-jet'.

Executive Ballroom 210H

14:00–16:00
SF3H • Microresonator Frequency Combs
Presider: Tara Drake; NIST, USA

SF3H.1 • 14:00 Invited
Optical Frequency Measurements with a Silica Disk Microcomb, Erin S. Lamb[1]; [1]*OFS, USA.* Aspects of reliable chip-scale frequency combs are discussed. A silica disk microcomb operating at 15 GHz and broadened in a silicon nitride waveguide is used to measure the frequency drift between two ultrastable reference lasers.

SF3H.2 • 14:30
Generation of Clustered Frequency Comb via Intermodal Four-Wave Mixing in an Integrated Si_3N_4 Microresonator, Ayman N. Kamel[1], Houssein El Dirani[2], Marco Casale[2], Sébastien Kerdiles[2], Carole Socquet-Clerc[2], Minhao Pu[1], Leif K. Oxenløwe[1], Kresten Yvind[1], Jesper Lægsgaard[1], Corrado Sciancalepore[2]; [1]*DTU, Denmark;* [2]*CEA-LETI, France.* We present the generation of a second harmonic wave and a clustered comb at 1μm from a telecom wavelength pump in a dispersion engineered Si_3N_4 microresonator.

Meeting Room 211 A/B | Meeting Room 211 C/D | Meeting Room 212 A/B | Meeting Room 212 C/D

CLEO: Science & Innovations

14:00–16:00
SF3I • Lasers for Accelerators
Presider: Lutz Winkelmann; DESY, Germany

SF3I.1 • 14:00
Update on BELLA Center's Free-Electron Laser driven by a Laser-Plasma Accelerator, Fumika Isono[1,2], Jeroen Van Tilborg[1], Sam Barber[1], Cameron Geddes[1], Hai-En Tsai[1], Carl Schroeder[1], Wim Leemans[1,2]; [1]*Lawrence Berkeley National Lab, USA;* [2]*Univ. of California, Berkeley, USA.* Technology to drive a free-electron laser with a compact laser-plasma accelerator is pursued. Recently we commissioned a new 5-Hz 100 TW laser, produced first electron beams (135 MeV), and built a dedicated FEL beamline, the status of which we report here.

SF3I.2 • 14:15
Laguerre-Gaussian Mode Laser Heater for Microbunching Instability Suppression in Free Electron Lasers, Jingyi Tang[1], Wei Liu[1], Randy Lemons[1], Sharon Vetter[1], Timothy Maxwell[1], Franz-Josef Decker[1], Alberto Lutman[1], Jacek Krzywinski[1], Gabriel Marcus[1], Stefan Moeller[1], Daniel Ratner[1], Zhirong Huang[1], Sergio Carbajo[1]; [1]*SLAC National Accelerator Lab, USA.* We report on the use of a Laguerre-Gaussian transverse mode in the LCLS laser heater resulting in better suppression of microbunching instability. We discuss the impact on FEL performance.

SF3I.3 • 14:30
Ptychographic Characterization of an Intense High-Harmonic-seeded Femtosecond Soft X-ray Laser, Michael Zurch[1,2], Frederik Tuitje[3], Tobias Helk[3], Julien Gautier[4], Fabien Tissandier[4], Jean-Philippe Goddet[4], Eduardo Oliva[5], Alexander Guggenmos[2], Ulf Kleineberg[6], Stephane Sebban[4], Christian Spielmann[3]; [1]*Dept. of Physical Chemistry, Fritz Haber Inst., Germany;* [2]*Chemistry Dept., Univ. of California at Berkeley, USA;* [3]*Friedrich Schiller Univ., Germany;* [4]*Laboratoire d'optique appliquée – ENSTA-ParisTech, France;* [5]*Departamento de Ingeniería Energética, ETSI Industriales, Universidad Politécnica de Madrid, Spain;* [6]*Ludwig-Maximilians-Universität München, Germany.* We report the direct wavefront characterization of an intense ultrafast high-harmonic-seeded soft X-ray laser (λ=32.8 nm) and monitor the laser plasma amplifier depending on the arrival time of the seed pulses by high-resolution ptychographic imaging.

14:00–16:00
SF3J • Metasurface & Plasmonic Structures
Presider: Takasumi Tanabe; Keio University, Japan

SF3J.1 • 14:00
All-dielectric Metasurfaces for Infrared Absorption Spectroscopy Applications, Aleksandrs Leitis[1], Andreas Tittl[1], Mingkai Liu[2], Filiz Yesilkoy[1], Duk-yong Choi[3], Dragomir Neshev[2], Yuri S. Kivshar[2], Hatice Altug[1]; [1]*Inst. of BioEngineering, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland;* [2]*Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia;* [3]*Laser Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia.* We present a nanophotonic method capable of detecting mid-infrared molecular fingerprints without the need for spectrometry. We leverage dielectric metasurfaces featuring ultrasharp resonances at discrete frequencies, enabling us to sample absorption signatures over the mid-IR spectral range.

SF3J.2 • 14:15
Dielectric Metasurface Comprising Color Hologram Encoded into a Color Printing Image, Dandan Wen[1], Jasper Cadusch[1], Jiajun Meng[1], Kenneth Crozier[1]; [1]*The Univ. of Melbourne, Australia.* We experimentally demonstrate a dielectric metasurface that simultaneously provides a color printing image (viewed with a brightfield microscope) and a far-field color hologram (viewed by illuminating the device by red/green/blue lasers).

SF3J.3 • 14:30 Invited
Achieving Light-Matter Interaction at Microcavity Q yet Plasmonic Mode Volumes, Femius Koenderink[1]; [1]*Center for Nanophotonics, AMOLF, Netherlands.* We study hybrid plasmonic-photonic resonators that combine subwavelength confinement of nano-antennas with the high Q of silicon-nitride microdisk cavities. Fluorescence of quantum dots localized at the antenna hot spots reveals significant hybrid-mode Purcell enhancement.

CLEO: Applications & Technology

14:00–16:00
AF3K • Imaging, Microscopy, & Specialized Detection
Presider: Gregory Rieker; University of Colorado at Boulder, USA

AF3K.1 • 14:00
Full-color, multi-plane image projection with mobile-phone flashlight & a multi-level diffractive hologram, Monjurul Meem[1], Rajesh Menon[1], Apratim Majumder[1]; [1]*Univ. of Utah, USA.* We show the projection of color and covert images in multiple planes using a multi-level diffractive-optical element illuminated by the flashlight of a mobile phone. Such devices could be useful for in secure documents.

AF3K.2 • 14:15
Holographic Speckle-Based Authentication Paradigm, Yoav Blau[1], Ofer Bar-On[1], Yael Hanein[1], Amir Boag[1], Jacob Scheuer[1]; [1]*Tel Aviv Univ., Israel.* An approach for a physical authentication scheme is proposed relying on the irreversible and nonconvex nature of computer-generated holograms. This is demonstrated by proof-of-principle meta-holograms projecting uniquely speckled 2D barcode images.

AF3K.3 • 14:30
Compressive Imaging with a Stochastic Spatial Light Modulator, Jason Schaake[1,3], Raphael C. Pooser[2], Stephen Jesse[4]; [1]*Quantum Information Science, Oak Ridge National Lab, USA;* [3]*Oak Ridge Assoscated Universities, USA;* [4]*Center for Nanophase Materials Science, Oak Ridge National Lab, USA.* We present a stochastic analog spatial light modulator designed for non-optical compressive imaging or spectroscopic applications where no spatial modulators exist. This spatial modulator does not require deterministic control.

CLEO: Science & Innovations

14:00–16:00
SF3L • Fiber Sensing
Presider: William Renninger; University of Rochester, USA

SF3L.1 • 14:00
Directional Curvature Sensing Using Multi-core Fiber Bragg Grating and Two-Photon Absorption Process in Si-APD, Yosuke Tanaka[1], Tetsuya Abe[1], Hiromasa Miyazawa[1]; [1]*Tokyo Univ of Agriculture and Technology, Japan.* We demonstrate a directional curvature sensor using a multicore fiber Bragg grating (FBG). The FBGs having almost the same Bragg wavelengths are discriminated by the distance measurement technique using two-photon absorption process in a Si-APD.

SF3L.2 • 14:15
Embedded-core optical fiber for distributed pressure measurement using an autocorrelation OFDR technique, Rodrigo M. Gerosa[2], Jonas H. Osório[1], Daniel Lopez-Cortes[2], Cristiano M. Cordeiro[1], Christiano J. de Matos[2]; [1]*Instituto de Física "Gleb Wataghin", Universidade Estadual de Campinas, Brazil;* [2]*MackGraphe – Graphene and Nanomaterials Research Center, Mackenzie Presbyterian Univ., Brazil.* We present a pressure sensor using an optical frequency domain reflectometer and a simplified microstructured fiber. High sensitivity, ease of fabrication and distributed sensing makes the proposed configuration a promising technique for pressure sensing applications.

SF3L.3 • 14:30
Dynamic coherent optical time-domain reflectometry with pulse compression, Ji Xiong[1], Yue Wu[1], Zinan Wang[1], Yun Jiang Rao[1]; [1]*Univ. Electronic Sci. & Tech. of China, China.* We report a novel COTDR using chirped pulse compression. By only adjusting the sweep range of the chirped pulse, the spatial resolution is changed from 5 m to 0.5 m, and dynamic strain sensing is also demonstrated.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

14:00–16:00
FF3M • Quantum Interactions in Nanophotonic Systems
Presider: Amit Agrawal, NIST, USA

FF3M.1 • 14:00
Coherent Interaction of Light with a Single Molecule and a Plasmonic Nanoparticle, Johannes Zirkelbach[1,2], Pierre Türschmann[1], Jan Renger[1], Tobias Utikal[1], Stephan Götzinger[1,2], Vahid Sandoghdar[1,2]; [1]*Sandoghdar Division, Max Planck Inst. for the Science of Light, Germany;* [2]*Physics, Friedrich Alexander Univ., Germany.* We demonstrate partial cloaking of a gold nanoparticle by a single organic molecule as a result of their coherent interaction with a monochromatic laser beam at cryogenic temperatures. Spectral and fluorescence lifetime analyses are presented.

FF3M.2 • 14:15
Quantum Electron-Photon Entanglement in the Strong-Coupling Regime, Ofer Kfir[1], Claus Ropers[1]; [1]*Univ. of Göttingen, Germany.* We investigate coherent interactions between cavity-photons and electrons at arbitrary coupling strengths, and propose a road-map to approach this regime experimentally. As an example, we explore photon-mediated entanglement of two free electrons.

FF3M.3 • 14:30 Invited
Quantum Approaches to Atomic-Scale Plasmon-Enhanced Molecular Spectroscopy, Javier Aizpurua[1]; [1]*Mat Physics Ctr. CSIC-UPV/ and DIPC, Spain.* The interaction between molecular excitations and plasmons can enhance and modify the spectral properties of a molecule. In this context, we address the importance of quantum effects produced by atomic-scale hot spots.

Marriott
Salon III

CLEO: Science & Innovations

14:00–16:00
SF3N • Modulators, Phase Arrays & Photodetectors
Presider: Jonathan Bradley; McMaster Univ., Canada

SF3N.1 • 14:00
$MoTe_2$ Vertical Heterostructure Waveguide Detector, Ping Ma[1], Nikolaus Flöry[1], Yannick Salamin[1], Alexandros Emboras[1], Takashi Taniguchi[2], Kenji Watanabe[2], Lukas Novotny[1], Jürg Leuthold[1]; [1]*ETH Zurich, Switzerland;* [2]*National Inst. for Material Science, Japan.* A high-speed waveguide-integrated photodetector based on $MoTe_2$ vertical heterostructure is demonstrated. The proposed photodetector features a measured 3 dB bandwidth of 25 GHz around 1310 nm.

SF3N.2 • 14:15
Tiled Silicon-Photonic Phased Array for Large-Area Apertures, Bohan Zhang[1], Nathan Dostart[2], Michael Brand[2], Anatol Khilo[1], Daniel Feldkhun[2], Milos Popovic[1,2], Kelvin Wagner[2]; [1]*Electrical and Computer Engineering, Boston Univ., USA;* [2]*Electrical, Computer and Energy Engineering, Univ. of Colorado, Boulder, USA.* We present the first demonstration of a tiling scheme to scale silicon photonic optical phased arrays to large-area beam steering apertures. We experimentally demonstrate two co-steering tiles - the first step towards a practical scheme to reach large area apertures.

SF3N.3 • 14:30
Hybrid Integration of Multi-band, Tunable External-Cavity Diode Lasers for Wide-Angle Beam Steering, Yeyu Zhu[1], Siwei Zeng[1], Yunsong Zhao[1], Lin Zhu[1]; [1]*Clemson Univ., USA.* We demonstrate hybrid integration of multi-band tunable external cavity diode lasers with a silicon nitride photonic chip. We realize wide-angle beam steering by using the extremely wide wavelength tuning range provided by multi-band diode lasers.

Marriott
Salon IV

14:00–16:00
SF3O • Saturable Absorber Materials & Chalcogenides
Presider: Tingyi Gu; Univ. of Delaware, USA

SF3O.1 • 14:00
Multiple-wavelength Q-switched Fiber Laser Using Synthetic Single-crystal Diamond Saturable Absorbe, Zheyuan Zhang[1], Yuanjun Zhu[1], Pengtao Yuan[1], Hongbo Jiang[1], Zihao Zhao[1], Fulin Xiang[1], Lei Jin[1], Sze Y. Set[1], Shinji Yamashita[1]; [1]*Univ. of Tokyo, Japan.* The saturable absorber properties of synthetic single-crystal diamond is demonstrated, and a Q-switched fiber laser using synthetic diamond as saturable absorber (SA) which could achieve multi-wavelength output is proposed and demonstrated.

SF3O.2 • 14:15
Er- and Tm-doped mode-locked fiber laser with a broadband, microfiber-based MOF saturable absorber, Qian Zhang[1], Meng Zhang[1], Xinxin Jin[1], Quanyu Jiang[1], Xiantao Jiang[2], Han Zhang[2], Zheng Zheng[1]; [1]*Beihang Univ., China;* [2]*Shenzhen Univ., China.* We demonstrate mode-locked pulse generation in erbium-doped and thulium-doped fiber lasers by using a microfiber-based metal–organic frameworks saturable absorber. Our results highlight the applicability of such nanomaterial as a broadband SA for ultrafast photonic applications.

SF3O.3 • 14:30
Thulium-doped mode-locked fiber laser with MXene saturable absorber, Quanyu Jiang[1], Meng Zhang[1], Qian Zhang[1], Xinxin Jin[1], Qing Wu[1], Xiantao Jiang[2], Han Zhang[2], Zheng Zheng[1]; [1]*Beihang Univ., China;* [2]*Shenzhen Univ., China.* We demonstrate an all-fiber thulium-doped mode-locked laser by using MXene as the saturable absorber, producing 2.11 ps pulses at 13.45 MHz repetition rate. Our work highlights the potential of MXene-based devices for future photonic technologies.

CLEO: QELS-Fundamental Science

Executive Ballroom 210A

FF3A • Single-Photon Collection & Characterization—Continued

FF3A.4 • 14:45
Emission Statistics and Optical Transition Dipoles of Semiconductor Nanoplatelets, Xuedan Ma[1], Benjamin Diroll[1], Igor Fedin[2], Wooje Cho[2], Dmitri Talapin[2,1]; [1]*Argonne National Lab, USA;* [2]*Dept. of Chemistry and James Franck Inst., Univ. of Chicago, USA.* We report on the emission statistics and optical transition dipoles of quasi-two-dimensional semiconductor nanoplatelets studied by single particle spectroscopy. We find that the emission properties of the nanoplatelets are strongly dependent on their lateral dimensions.

FF3A.5 • 15:00 Invited
Crummy Measurements and Lousy Copies: Methods to Simultaneously Measure X and P In Order to Directly Observe the Quantum Wavefunction, Jeff S. Lundeen[1]; [1]*Univ. of Ottawa, Canada.* We measure position and momentum on a single photon using two methods: weak measurements and optimal quantum-cloning. We demonstrate that either method directly measures the wavefunction so that its real and imaginary components appear straight on our measurement apparatus.

FF3A.6 • 15:30
Quantum, Nonlocal Aberration Cancellation, Andy N. Black[1], Enno A. Giese[4], Boris Braverman[2], Nicholas Zollo[3], Robert Boyd[1,2]; [1]*Dept. of Physics and Astronomy, Univ. of Rochester, USA;* [2]*Dept. of Physics, Univ. of Ottawa, Canada;* [3]*The College of Optics and Photonics, Univ. of Central Florida, USA;* [4]*Inst. for Quantum Physics, Ulm Univ., Germany.* We demonstrate the effects of aberration and nonlocal aberration cancellation on a photonic transverse entanglement measurement. This technique can be applied to realize nonlocal aberration correction in ghost imaging.

Executive Ballroom 210B

FF3B • Disordered Media—Continued

FF3B.4 • 14:45
Anderson Localization in Nearly-periodic and Strongly Disordered Finite-supported Systems, Randhir Kumar[1], Sandip Mondal[1], M Balasubrahmaniyam[1], Martin Kamp[2], Sushil A. Mujumdar[1]; [1]*Tata Inst. of Fundamental Research, India;* [2]*Lehrstuhl fuer Technische Physik, Univ. of Wuerzburg , Germany.* We experimentally demonstrate two-dimensional Anderson localization of light in two disorder regimes, namely, in nearly-periodic disorder, and in strong disorder. Measurement of generalized conductance fluctuations demarcates hitherto-unknown differences between the two regimes.

FF3B.5 • 15:00
Transverse localization of transmission eigenchannels in the diffusive regime, Hasan Yilmaz[1], Chia Wei Hsu[1], Alexey Yamilov[2], Hui Cao[1]; [1]*Yale Univ., USA;* [2]*Dept. of physics, Missouri Univ. of Science & Technology, USA.* We discover transverse localization of transmission eigenchannels in wide diffusive slabs and study the scaling of eigenchannel widths. Such localization enhances energy densities inside turbid media, which are important for light-matter interactions and imaging applications.

FF3B.6 • 15:15
Disorder-Immune Photonics Based on Mie-Resonant Dielectric Metamaterials, Changxu Liu[1,2], Mikhail Rybin[3], Peng Mao[1], Shuang Zhang[1], Yuri S. Kivshar[2]; [1]*Univ. of Birmingham, UK;* [2]*Australian National Univ., Australia;* [3]*Ioffe Inst., Russia.* We study periodic lattices of silicon nanorods and introduce the concept of a phase diagram characterizing the regimes of photonic crystals and metamaterials. We unveil a novel regime with a robust bandgap which can endure disorder beyond 30% of the lattice constant.

FF3B.7 • 15:30
Delay Time inside Disordered 1D Media, Yiming Huang[1,2], Azriel Z. Genack[1,2]; [1]*Queens College of CUNY, USA;* [2]*Physics, Graduate Center of CUNY, USA.* Microwave measurements and simulations show that the ensemble average of the delay time of waves inside disordered 1D media increases linearly with depth with a slope equal to the inverse of the group velocity.

Executive Ballroom 210C

FF3C • Attosecond Dynamic Imaging—Continued

FF3C.3 • 14:45
Glory rescattering in strong-field atomic ionization, Qinzhi Xia[1], Jianfei Tao[2], Jun Cai[3], Libin Fu[4], Jie Liu[1]; [1]*IAPCM, China;* [2]*Beijing Computational Science Research Center, China;* [3]*Jiangsu Normal Univ., China;* [4]*Graduate School of China Academy of Engineering Physics, China.* Glory rescattering is discovered in strong field atomic ionization. By developing glory rescattering theory, we resolve the discrepancies between theories and experiments on holographic patterns, and shed light on the quantum interference aspects of LES.

FF3C.4 • 15:00
Streaking of Argon L-shell Auger emissions with > 250 eV attosecond X-ray pulses, Seunghwoi Han[1], Peng Xu[2], Yishan Wang[2], Kun Zhao[3], Zenghu Chang[1]; [1]*CREOL and Dept. of Physics, Univ. of Central Florida (UCF), USA;* [2]*State Key Lab of Transient Optics and Photonics, Xi'an Inst. of Optics and Precision Mechanics,CAS, China;* [3]*Inst. of Physics, Chinese Academy of Sciences, China.* We investigate the Argon Auger decay using isolated attosecond X-ray pulses reach the Carbon K-edge. A home-built electron spectrometer resolves and measures lifetimes of L-shell vacancies of Argon in pump-probe experiment.

FF3C.5 • 15:15
Ultrafast Ring-Opening Dynamics of 1,3-cyclohexadiene Probed via Time-Resolved High-Harmonic Spectroscopy, Keisuke Kaneshima[1], Yuki Ninota[1], Taro Sekikawa[1]; [1]*Hokkaido Univ., Japan.* We demonstrate the simultaneous observation of the electronic and vibrational dynamics of the photo-isomerizing 1,3-cyclohexadiene via high-harmonic spectroscopy. The attosecond high-harmonic interference reveals how the excited-state ionization potential evolves along the reaction coordinate.

FF3C.6 • 15:30
Tracking the Phase Transition in VO_2 using High Harmonic Spectroscopy, Mina Bionta[1], Adrien Leblanc[1], Vincent Gruson[1,2], Philippe Lassonde[1], Jérémie Chaillou[1], Nicolas Émond[1], Martin R Otto[3], Bradley J Siwick[3], Mohamed Chaker[1], François Légaré[1]; [1]*INRS-Energie Mat & Tele Site Varennes, Canada;* [2]*Physics, The Ohio State Univ., USA;* [3]*Physics and Chemistry, McGill, Canada.* We investigate the dynamics of the insulator-to-metal phase transition in VO_2 with high temporal resolution using a new method of time-resolved high harmonic spectroscopy in a solid-state system, revealing all electronic states involved.

Executive Ballroom 210D

FF3D • Nonlinear & Quantum Effects—Continued

FF3D.4 • 14:45
Observing Quantum Turbulent Structure in Laser Speckle, Samuel Alperin[1,2], Abigail Grotelueschen[1], Mark Siemens[1]; [1]*Univ. of Denver, USA;* [2]*Univ. of Cambridge, UK.* We demonstrate both experimentally and numerically that vortices in laser speckle obey the same velocity statistics as in turbulent quantum fluids, thus linking the seemingly-disparate fields of classical optics and quantum fluid dynamics.

FF3D.5 • 15:00
Romdom vs. quasi phase matching: frequency conversion in zinc-blende polycrystals, experiment and theory, Taiki Kawamori[1], Qitian Ru[1], Xuan Chen[1], Konstantin L. Vodopyanov[1]; [1]*Univ. of Central Florida, USA.* We develop a model for random-phase matching which takes into account effects of random crystal orientation and grain size fluctuations and show that for ultrafast interactions, random-phase matching can be as efficient as quasi-phase matching.

FF3D.6 • 15:15
Compact quantum imaging based on induced coherence, Marta Gilaberte Basset[1], Josué R. Léon Torres[1], Markus Graefe[1]; [1]*Fraunhofer Inst. for Applied Optics and Precision Engineering IOF, Germany.* We report on a compact single-crystal setup for quantum imaging based on induced coherence without induced emission. Our first results will pave the way towards extreme light imaging devices for life science.

FF3D.7 • 15:30
Quantum Radiation from Electrons in Strong Fields, Morgan H. Lynch[1], Ori Reinhardt[1], Nicholas Rivera[2], Ido Kaminer[1]; [1]*Electrical Engineering, Technion - Israel Inst. of Technology, Israel;* [2]*Physics, Massachusetts Inst. of Technology, USA.* We present a mechanism for generating ultrashort high-harmonic radiation pulses in electron microscopes. At the core of this mechanism are transitions between electronic Floquet states formed in the strong nearfield of a nanophotonic structure.

Executive Ballroom 210E

CLEO: Science & Innovations

SF3E • Ultrafast Oscillators—Continued

SF3E.4 • 14:45
21 W average power sub-100-fs Yb:Lu_2O_3 thin-disk laser, Norbert Modsching[1], Jakub Drs[1], Julian Fischer[1], Clément Paradis[1], François Labaye[1], Maxim Gaponenko[1], Christian Kränkel[2], Valentin J. Wittwer[1], Thomas Südmeyer[1]; [1]*Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland;* [2]*Center for Laser Materials, Leibniz-Institut für Kristallzüchtung, Germany.* We demonstrate a Kerr lens mode-locked thin-disk laser oscillator operating with 95-fs pulses at 21.1 W of average power. This is the highest average power achieved by any oscillator in the sub-100-fs regime.

SF3E.5 • 15:00
Three-element-cavity enables Kerr-lens mode-locking at 20-GHz repetition rate, Shota Kimura[1], Shuntaro Tani[1], Yohei Kobayashi[1]; [1]*The Univ. of Tokyo, Japan.* We propose a new cavity design for a compact Kerr-lens mode-locked laser using only three optical elements. The repetition rate of 20 GHz was achieved with the pulse duration of 120 fs.

SF3E.6 • 15:15
Graphene mode-locked Tm,Ho:CLNGG laser with 70-fs pulse duration, Yongguang Zhao[1], Weidong Chen[1], Valentin Petrov[1], Li Wang[1], Yicheng Wang[1], Zhongben Pan[1], Xiaojun Dai[2], Hualei Yuan[2], Yan Zhang[2], Huaqiang Cai[2], Ji Eun Bae[3], Sun Young Choi[3], Fabian Rotermund[3], Pavel Loiko[4], Josep Serres[5], Xavier Mateos[5], Wei Zhou[6], Deyuan Shen[6], Uwe Griebner[1]; [1]*Max-Born Inst., Germany;* [2]*China Academy of Engineering Physics, China;* [3]*Dept. of Physics, South Korea Advanced Inst. of Science and Technology (KAIST), South Korea (the Republic of);* [4]*ITMO Univ., Russia;* [5]*Universitat Rovira i Virgili, Spain;* [6]*Jiangsu Normal Univ., China.* We report on a mode-locked Tm,Ho:CLNGG laser employing graphene as a saturable absorber. Pulses as short as 70 fs, i.e., 10 optical cycles, are generated at 2093 nm with a repetition rate of ~89 MHz.

SF3E.7 • 15:30
Sub-10 fs Pulse Generation From a Blue-Diode-Pumped Kerr-Lens Mode-Locked Ti:sapphire Laser, Han Liu[1], Geyang Wang[1], Ke Yang[1], Renzhu Kang[1], Wenlong Tian[1], Dacheng Zhang[1], Liang Guo[1], Jiangfeng Zhu[1], Zhiyi Wei[2]; [1]*Xidian Univ., China;* [2]*Chinese Academy of Sciences, Beijing National Lab for Condensed Matter Physics, Inst. of Physics, China.* We demonstrate a blue-diode pumped Kerr-lens mode-locked Ti:sapphire laser generating sub-10 fs pulses for the first time. The laser is centered at 830 nm with 113 nm bandwidth and 22 mW average power.

Executive Ballroom 210F

Joint

JF3F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect III—Continued

JF3F.2 • 15:00 Invited
Training of Photonic Neural Networks through *In Situ* Backpropagation, Tyler Hughes[1], Momchil Minkov[1], Ian Williamson[1], Yu Shi[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We provide a protocol for training photonic neural networks based on adjoint methods. The gradient of the network with respect to its tunable degrees of freedom is computed by physically backpropagating an optical error signal.

JF3F.3 • 15:30 Invited
Deep Imaging Cytometry. Yueqin Li[1], Ata Mahjoubfar[1], Bahram Jalali[1], Kayvan Niazi[2]; [1]*UCLA, USA,* [2]*Nantworks, USA.* We describe a new implementation of our deep learning time-stretch imaging flow cytometry which avoids data pre-processing and feature extraction. The neural network classifies cancer cells by directly processing the raw serial temporal data.

Executive Ballroom 210G

CLEO: Science & Innovations

SF3G • Laser-Based 2D/3D Micro- & Nano-fabrication—Continued

SF3G.4 • 14:45
Two-photon induced chiral mass-transport of azo-polymers as a function of pulse duration, Keigo Masuda[1], Yoshinori Kinezuka[1], Mitsuki Ichijo[1], Ryo Shinozaki[1], Keisaku Yamane[2], Kohei Toyoda[1,3], Katsuhiko Miyamoto[1,3], Takashige Omatsu[1,3]; [1]*Chiba Univ., Japan;* [2]*Hokkaido Univ., Japan;* [3]*MCRC Chiba Univ., Japan.* We demonstrated two-photon-absorption induced chiral surface relief formation in an azo-polymer film by illumination of picosecond 1-μm optical vortex pulses. The chiral surface relief formation required at least several times the response-time of trans-cis isomerization.

SF3G.5 • 15:00 Invited
Functionalizing Glass by Local Compositional Tuning with Ultrafast Lasers, Javier Solis[1]; [1]*Instituto De Optica 'Daza De Valdes', Spain.* The presentation provides an overview of fs-laser induced ion migration phenomena in glass, with emphasis on recent results of our research group regarding its application for the production of efficient photonic devices.

SF3G.6 • 15:30
Rapid Femtosecond Laser 3D microfabrication using Focal Field Engineering, Yan Li[1], Dong Yang[1], Lipu Liu[1], Hong Yang[1], Qihuang Gong[1]; [1]*Peking Univ., China.* We realize the single-exposure and the single-scan femtosecond laser microfabrication of 3D microstructures by the 3D focal field intensity engineering. The two rapid techniques are further integrated to fabricate a microstructure.

Executive Ballroom 210H

SF3H • Microresonator Frequency Combs—Continued

SF3H.3 • 14:45
Si-chip frequency combs with 2-octaves bandwidth for longwave-IR gas and liquid dual-comb spectroscopy, Nima Nader[1], Jeff Chiles[1], Henry Timmers[1], Eric J. Stanton[1], Abijith Kowligy[1], Alexander Lind[1,2], Sae Woo Nam[1], Scott A. Diddams[1,2], Richard P. Mirin[1]; [1]*National Inst. of Standards and Tech, USA;* [2]*Physics, Univ. Of Colorado, Boulder, USA.* We use suspended-silicon waveguides for spectral engineering of mid-infrared frequency combs to achieve spectra spanning 2.0 octaves (2-8.5 μm). We demonstrate dual-comb spectroscopy of gas and liquid-phase samples with 100 MHz comb-line resolution.

SF3H.4 • 15:00
Silicon-Chip-Based *f-2f* Interferometer, Yoshitomo Okawachi[1], Mengjie Yu[1,2], Jaime Cardenas[1], Xingchen Ji[1,2], Michal Lipson[1], Alexander Gaeta[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA.* Using a single silicon-nitride waveguide, we demonstrate an *f-2f* interferometer for carrier-envelope-offset frequency (f_{CEO}) detection by simultaneous supercontinuum generation and second-harmonic generation. We measure a f_{CEO} beatnote with a 27-dB SNR with 62-pJ pulse energies.

SF3H.5 • 15:30
Microwatt-Level Soliton Frequency Comb Generation in Microresonators Using an Auxiliary Laser, Shuangyou Zhang[1], Jonathan M. Silver[1], Leonardo Del Bino[1], Francois Copie[1], Michael T. M. Woodley[1], George Ghalanos[1], Andreas Svela[1], Niall Moroney[1], Pascal DelHaye[1]; [1]*National Physical Lab, UK.* We report a simple and robust method to generate soliton frequency combs in microresonators assisted by an auxiliary laser. Our method significantly enhances the soliton access range and enables threshold powers down to 780 microwatt.

Meeting Room 211 A/B

Meeting Room 211 C/D

Meeting Room 212 A/B

Meeting Room 212 C/D

CLEO: Science & Innovations

SF3I • Lasers for Accelerators—Continued

SF3I.4 • 14:45
Flexible Pulse-Shape Picosecond Front-End for XFEL Photocathode Lasers, Chen Li[1], Lutz Winkelmann[1], Ingmar Hartl[1]; [1]*Deutsches Elektronen-Synchrotron, Germany.* X-ray Free-Electron Lasers rely on low-emittance photo-injectors driven by UV laser pulses. For optimum performance, temporally shaped laser pulses are desired. Here we present a laser front-end which delivers NIR ps-laser pulses of arbitrary pulse-envelope.

SF3I.5 • 15:00 Invited
Precision Synchronization for large scale Accelerators, Julien Branlard[1], Lukasz Butkowski[1], Marie Kristin Czwalinna[1], Matthias Felber[1], Tomasz Kozak[1], Thorsten Lamb[1], Frank Ludwig[1], Uros Mavric[1], Jost Mueller[1], Sven Pfeiffer[1], Christian Schmidt[1], Sebastian Schulz[1], Cezary Sydlo[1], Mikheil Titberidze[1], Holger Schlarb[1]; [1]*DESY, Germany.* Large scale accelerators such as the European X-ray Free Electron Lasers (XFEL) require femtosecond synchronization over kilometer distance to carry-out complex X-ray photon experiments with high temporal resolution. Recent implementations are summarized in this talk.

SF3I.6 • 15:30
Arrival Time Stabilization of the Photocathode Laser at the European XFEL, Jost Mueller[1], Sebastian Schulz[1], Lutz Winkelmann[1], Marie Kristin Czwalinna[1], Ingmar Hartl[1], Holger Schlarb[1]; [1]*DESY, Germany.* Arrival time drifts of the European XFEL photocathode laser pulses were identified using balanced optical cross-correlation and compared to the electron bunch arrival time changes. With a feedback loop this timing error could be compensated to 45 fs.

SF3J • Metasurface & Plasmonic Structures—Continued

SF3J.4 • 15:00
Optical Chirality Tunable and Reversable Plasmonic Chiral Metasurfaces on Flexible PDMS Substrate, Hsiang-Ting Lin[1], Yao-Yu Hsu[1,2], Chiao-Yun Chang[1], Min-Hsiung Shih[1,2]; [1]*Research Center for Applied Sciences, Academia Sinica, Taiwan;* [2]*Dept. of Photonics and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan.* We demonstrated a flexible plasmonic chiral metasurface which realized optical chirality both tunable and reversable. The controllable circular dichroism from -25% to +30% was achieved in the same metasurface under different stretch situations.

SF3J.5 • 15:15
Dispersion-Engineered Metasurfaces for Aberration-Corrected Spectroscopy, Alexander Y. Zhu[1], Wei-Ting Chen[1], Jared Sisler[1,2], Kerolos M. Yousef[1,3], Eric Lee[1,2], Yao-Wei Huang[1,4], Cheng-wei Qiu[4], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*Univ. of Waterloo, Canada;* [3]*College of Biotechnology, Misr Univ. of Science and Technology, Egypt;* [4]*National Univ. of Singapore, Singapore.* We report a miniature aberration-corrected spectrometer comprised of dispersion-engineered off-axis metasurface lenses. It possesses close to diffraction-limited spot sizes across 200 nm in the visible and has nanometer spectral resolution, despite a 4cm beam-propagation distance.

SF3J.6 • 15:30
Metasurface-based Waveplates Demonstrated on 300 mm Si CMOS Platform, Yuan Dong[1], Zhengji Xu[1], Jinchao Tong[2], Yuan-Hsing Fu[1], Qize Zhong[1], Vladimir Bliznetsov[1], Ting Hu[1], Yu Li[1], Shiyang Zhu[1], Qunying Lin[1], Dao Hua Zhang[2], Navab Singh[1]; [1]*Inst. of Microelectronics, Singapore;* [2]*Nanyang Technological Univ., Singapore.* Metasurface-based all-Si waveplates are first demonstrated on 300 mm CMOS platform. The cross- and co-polarization transmittances are characterized. A polarization conversion efficiency of 87% is achieved near 1.6 µm-wavelength.

CLEO: Applications & Technology

AF3K • Imaging, Microscopy, & Specialized Detection—Continued

AF3K.4 • 14:45
Improvement of Image Quality in Dual-Comb Microscopy by Post-Amplification of Dual Comb Lights, Takahiko Mizuno[1,2], Takuya Tsuda[1,2], Eiji Hase[1,2], Takeo Minamikawa[1,2], Hirotsugu Yamamoto[2,3], Takeshi Yasui[1,2]; [1]*Tokushima Univ., Japan;* [2]*JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan;* [3]*Utsunomiya Univ., Japan.* We combine dual-comb microscopy and post-amplification technique for rapid acquisition of confocal amplitude and phase images. The proposed method significantly improves signal-to-noise ratio in the rapid scan-less imaging.

AF3K.5 • 15:00
Near-Infrared Molecular Fieldoscopy, Ayman Alismail[1], Haochuan Wang[1], Gaia Barbiero[1], Syed Ali Hussain[1], Wolfgang Schweinberger[1], Ferenc Krausz[1], Hanieh Fattahi[1]; [1]*Max-Planck-Institut fur Quantenoptik, Germany.* In this work, the concept of near-infrared molecular fieldoscopy is introduced and bench-marking measurements are presented. The new method allows for high-resolution overtone spectroscopy and microscopy with an unparalleled sensitivity and specificity over the entire molecular fingerprint region.

AF3K.6 • 15:15
Time-stretch Network Analyzer for Single-shot Characterization of Electronic Devices, Zhuoya Bai[1], Cejo K. Lonappan[1], Asad M. Madni[1], Bahram Jalali[1]; [1]*Electrical and Computer Engineering, Univ. of California, Los Angeles, USA.* An optically-assisted single-shot instrument with automated Tikhonov calibration for measuring the complex frequency response of electronic devices is presented. High-throughput characterization of microwave amplifiers at 37 million impulse response measurements per second is demonstrated.

AF3K.7 • 15:30
Sub-nanosecond Pulsed Quantum Cascade Laser Driver, Mateusz Zbik[1]; [1]*VIGO System S.A., Poland.* A QCL modulator based on a pair of pulsed HEMT transistors was designed to test the high-speed VIGO System HgCdTe photodetectors response time. A drive current and optical pulse width of approximately 1A and 100ps, respectively, were achieved.

CLEO: Science & Innovations

SF3L • Fiber Sensing—Continued

SF3L.4 • 14:45
Phase Noise Compensation for Ultra-highly Sensitive Fiber-optic Quasi-distributed Acoustic Sensing System, Mengshi Wu[1], Xinyu Fan[1], Zuyuan He[1]; [1]*Shanghai Jiao Tong Univ., China.* An ultra-highly sensitive quasi-distributed acoustic sensing system is proposed with a phase-noise-compensated configuration, which gives a 11.55 dB improvement to the sensitivity. A sensitivity of 92.84 fε/ √ Hz @ 500-2500 Hz is achieved along a 20-km weak reflector array with 20-m spacing.

SF3L.5 • 15:00 Invited
Integrated Fibre Detection Architectures for Distributed Quantum Magnetometry, Shai Maayani[1], Christopher Foy[1], Dirk R. Englund[1], Yoel Fink[1]; [1]*MIT, USA.* Here, we constructed a water-immersible 90-meter-long fully-integrated fiber system that allows distributed quantum magnetic sensing over large distances with a sensitivity of 63 nT $Hz^{-1/2}$. Applications include remote detection of ferrous metals, geophysics, and biosensing.

SF3L.6 • 15:30
Twist Sensor Using Chiral Long-Period Grating Written in the Double-Cladding Fiber, Chen Jiang[1], Yunqi Liu[1], Chengbo Mou[1], Tingyun Wang[1]; [1]*Shanghai Univ., China.* We present the fabrication of a chiral long-period grating in twisted double-cladding fiber using CO2-laser. The near-filed intensity distribution and twist sensing characteristics of the proposed device were investigated experimentally.

CLEO: QELS-Fundamental Science

FF3M • Quantum Interactions in Nanophotonic Systems—Continued

FF3M.4 • 15:00
Tip Enhanced Strong Coupling of a Single Emitter at Room Temperature, Molly A. May[1], Kyoung-Duck Park[1], Haixu Leng[2], Jaron A. Kropp[2], Theodosia Gougousi[2], Matthew Pelton[2], Markus B. Raschke[1]; [1]*Dept. of Physics, Dept. of Chemistry, and JILA, Univ. of Colorado Boulder, USA;* [2]*Dept. of Physics, Univ. of Maryland, USA.* We use a configurable plasmonic nano-cavity with a nanoscopic mode volume to achieve and control strong coupling to a single quantum dot under ambient conditions using tip-enhanced photoluminescence spectroscopy.

FF3M.5 • 15:15
Tapered atomic cladded nano waveguide for fine control of light-atom interaction, Roy T. Zektzer[1], Noa Mazurski[1], Yefim Barash[1], Uriel Levy[1]; [1]*The Hebrew Univ. of Jerusalem, Israel.* We experimentally demonstrate the chip-scale integration of tapered nano waveguides and rubidium atoms. The optical mode interaction volume with the atoms is controlled by the tapering, giving rise to sub-Doppler atomic features and controlled interactions.

FF3M.6 • 15:30
Imaging the collapse of electron wave-functions: the relation to plasmonic losses, Chen Mechel[1], Yaniv Kurman[1], Aviv Karnieli[3], Nicholas Rivera[2], Ady Arie[3], Ido Kaminer[1]; [1]*Technion, Israel;* [2]*MIT, USA;* [3]*Tel Aviv Univ., Israel.* We show how free-electron interaction with plasmons in electron microscopes leads to electron-plasmon entanglement, connecting electron decoherence with plasmonic losses. We utilize this connection to propose a new method to probe plasmonic lifetimes.

CLEO: Science & Innovations

SF3N • Modulators, Phase Arrays & Photodetectors—Continued

SF3N.4 • 14:45
Acousto-Optic Modulator based on the Integration of Arsenic Trisulfide Photonic Components with Lithium Niobate Surface Acoustic Waves, Mdshofiqulislam Khan[1], Ashraf Mahmoud[1], Lutong Cai[1], Mohamed Mahmoud[1], Tamal Mukherjee[1], James Bain[1], Gianluca Piazza[1]; [1]*Carnegie Mellon Univ., USA.* An acousto-optic modulator formed by an Arsenic Trisulfide (As_2S_3) Mach-Zehnder interferometer placed inside a surface acoustic wave cavity on a Lithium Niobate (LN) wafer is demonstrated for the first time.

SF3N.5 • 15:00
Metalens-enabled Low-power Solid-state 2D Beam Steering, You-Chia Chang[2,1], Min Chul Shin[2], Christopher T. Phare[2], Steven A. Miller[2], Euijae Shim[2], Michal Lipson[2]; [1]*Dept. of Photonics and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan;* [2]*Electrical Engineering, Columbia Univ., USA.* We demonstrate a platform for low-power solid-state beam steering in 2D using a single wavelength. This platform, based on a metalens and a switchable emitter array, enables steering of 12.4°×26.8° using less than 83 mW.

SF3N.6 • 15:30
True Time Delay Millimeter Wave Beam Steering with Integrated Optical Beamforming Network, Yuan Liu[1], Brandon Isaac[1], Jean Kalkavage[2], Eric Adles[2], Thomas Clark[2], Jonathan Klamkin[1]; [1]*Univ. of California Santa Barbara, USA;* [2]*The Johns Hopkins Univ. Applied Physics Lab, USA.* Abstract A 94 GHz 1x4 phased array antenna with true time delayed integrated optical beamforming network was demonstrated. Steering angles of -51°, +/-32°, +/-15°, and 0° were achieved with excellent beam quality.

SF3O • Saturable Absorber Materials & Chalcogenides—Continued

SF3O.4 • 14:45
High Power Tolerant SWCNT-BNNT Saturable Absorber for Laser Mode-Lockin, Pengtao Yuan[1], Zheyuan Zhang[1], Shoko Yokokawa[1], Yongjia Zheng[2], Lei Jin[1], Sze Y. Set[1], Shigeo Maruyama[2], Shinji Yamashita[1]; [1]*Research Center for Advanced Science and Technology, Univ. of Tokyo, Japan;* [2]*Departure of Mechanical Engineering, The Univ. of Tokyo, Japan.* We demonstrate a mode-locked fiber laser using BN-wrapped SWCNT as a high power-tolerant saturable absorber. The new saturable absorber shows a significantly higher optical damage threshold and a great potential for various high-power optical applications.

SF3O.5 • 15:00
Micromachining of chalcogenide waveguides by picosecond laser, Dun Mao[1], Mingkun Chen[2,1], Nathan Augenbraun[1], Anishkumar Soman[1], Xiangyu Ma[1], Thomas Kananen[1], Matthew Doty[1], Tingyi Gu[1]; [1]*Univ. of Delaware, USA;* [2]*Univ. of Rochester, USA.* Direct laser inscription creates waveguide structures on chalcogenide thin film. Results of $Ge_2Sb_2Te_5$ and $Ge_{23}Sb_7Se_{70}$ are compared by varying laser powers and translation speeds.

SF3O.6 • 15:15
Integration of Nanoimprint and Silver Doping Lithography for Chalcogenide Photonic Crystal Slabs, Le Wei[1], Meng Lu[1], Liang Dong[1]; [1]*Iowa State Univ., USA.* We report a novel nanofabrication approach that combines the imprinting and silver doping lithography processes to pattern chalcogenide materials. The approach can fabricate 3D nanoscale structures in chalcogenide thin film for nanophotonic devices and sensors.

SF3O.7 • 15:30
Complete Photonic Bandgap in Lowest Index Contrast Inverse Rod-Connected Diamond Structured Chalcogenides, Lifeng Chen[1,2], Katrina Morgan[3], Chung-Che Huang[3], Ying-Lung Daniel Ho[1], Mike P. C. Taverne[1], Daniel W. Hewak[3], John G. Rarity[1]; [1]*Univ. of Bristol, UK;* [2]*Sun Yat-Sen Univ., China;* [3]*Univ. of Southampton, UK.* We present an inverse rod-connected diamond structure showing a complete bandgap with refractive index contrast down to n_{high}/n_{low} ~ 1.9. The structures were fabricated using a low-temperature chemical vapor deposition process, via a single-inversion technique.

Executive Ballroom 210A	Executive Ballroom 210B	Executive Ballroom 210C	Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FF3A • Single-Photon Collection & Characterization—Continued

FF3A.7 • 15:45
Direct Detection of Quantum Phase Errors in Spatially Multiplexed Transmission Channels, Kai Wang[1,2], Falk Eilenberger[3,4], Alexander Szameit[2], Andrey A. Sukhorukov[1]; [1]*Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia;* [2]*Inst. for Physics, Rostock Univ., Germany;* [3]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ., Germany;* [4]*Center for Excellence in Photonics, Fraunhofer Inst. for Applied Optics and Precision Engineering IOF, Germany.* We introduce a protocol for direct detection of arbitrary continuous phase errors in transmission of multi-photon spatially entangled quantum states, and present a design and experimental evidence for its realization in an integrated photonic circuit.

FF3B • Disordered Media—Continued

FF3B.8 • 15:45
A Novel Phase-Map to Increase the Efficiency of Random Metasurfaces, Hadiseh Nasari[1], Matthieu Dupré[1], Boubacar Kanté[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of California San Diego, USA.* We report on using a statistical approach to obtain a novel phase-map addressing the near-field coupling between elements and improving the efficiency of random metasurfaces compared to the conventional ones designed by periodic phase-map.

FF3C • Attosecond Dynamic Imaging—Continued

FF3D • Nonlinear & Quantum Effects—Continued

FF3D.8 • 15:45
Withdrawn

Executive Ballroom 210E

CLEO: Science & Innovations

SF3E • Ultrafast Oscillators—Continued

Executive Ballroom 210F

Joint

JF3F • Symposium on Deep-learning Photons: Where Machine Learning & Photonics Intersect III—Continued

Executive Ballroom 210G

CLEO: Science & Innovations

SF3G • Laser-Based 2D/3D Micro- & Nano-fabrication—Continued

SF3G.7 • 15:45
Direct Printing of Gold Nano-Particles by Laser Induced Dewetting, Jae Hyuck Yoo[1], Nathan Ray[1], Hoang Nguyen[1], Mike Johnson[1], Sal Baxamusa[1], Selim Elhadj[1], Joseph Mckeown[1], Manyalibo J. Matthews[1], Eyal Feigenbaum1[1]; [1]*LLNL, USA.* Arbitrary patterns, consisting of sub-wavelength sized nano particles, are developed by laser induced dewetting of ultrathin gold films (*e.g.,* 5, 7.5, and 10 nm). We demonstrate that the light induced local temperature determines the resulting dewetting structures.

Executive Ballroom 210H

SF3H • Microresonator Frequency Combs—Continued

SF3H.6 • 15:45
Broadband High-Resolution Scanning of Soliton Micro-Combs, Tong Lin[1], Avik Dutt[1], Xingchen Ji[1], Chaitanya Joshi[1], Alexander Gaeta[1], Michal Lipson[1]; [1]*Columbia Univ., USA.* We demonstrate continuous scanning of a single soliton micro-comb over 88 GHz with an instantaneous linewidth of 60 kHz. We show such a system can acquire spectra of HCN with a high spectral-resolution.

Meeting Room 211 A/B	Meeting Room 211 C/D	Meeting Room 212 A/B	Meeting Room 212 C/D
CLEO: Science & Innovations		CLEO: Applications & Technology	CLEO: Science & Innovations

SF3I • Lasers for Accelerators—Continued

SF3I.7 • 15:45
High-sensitivity X-ray Optical Cross-Correlator for Next Generation Free-Electron Lasers, Stefan Droste[1], Lingjia Shen[1], Vaughn E. White[1], Elizabeth Diaz-Jacobo[1], Ryan Coffee[1], Sioan Zohar[1], Alexander Reid[1], Franz Tavella[1], Michael P. Minitti[1], Joshua Turner[1], Karl Gumerlock[1], Alan Fry[1], Giacomo Coslovich[1]; [1]*SLAC / Stanford, USA.* We designed a novel X-ray arrival time monitor that cross-correlates X-ray and 1550nm optical pulses. We exploit an interferometric detection scheme and etalon effects in thin-film Germanium to achieve unprecedented high sensitivity to soft X-rays.

SF3J • Metasurface & Plasmonic Structures—Continued

SF3J.7 • 15:45
Direct laser writing of optical field concentrators based on chirped three-dimensional photonic crystals, Vygantas Mizeikis[1], Zeki Hayran[2], Hamza Kurt[2], Mirbek Turduev[3], Darius Gailevicius[4], Mangirdas Malinauskas[4], Saulius Juodkazis[5], Kestutis Staliunas[6]; [1]*Research Inst. of Electronics, Shizuoka Univ., Japan;* [2]*TOBB Univ. of Economics and Technology, Turkey;* [3]*TED Univ., Turkey;* [4]*Vilnius Univ., Lithuania;* [5]*Swinburne Univ. of Technology, Australia;* [6]*Institució Catalana de Recerca i Estudis Avancats, Spain.* 3D chirped photonic crystals for applications as electromagnetic field concentrators at optical frequencies were fabricated using Direct Laser Write technique, their optical properties and finctionality were characterized experimentally.

AF3K • Imaging, Microscopy, & Specialized Detection—Continued

AF3K.8 • 15:45
Ultrafast UV Metal–Seminconductor–Metal Photodetector Based on AlGaN with a Response Time Below 20 ps, Yiming Zhao[1]; [1]*Lab for Laser Energetis, USA.* AlGaN UV photodetectors were fabricated with micrometer scale metal–semiconductor–metal structures and tested with an ultrafast 263-nm laser. The best performance devices showed a fast response time of below 20 ps and dark currents below 10 pA.

SF3L • Fiber Sensing—Continued

SF3L.7 • 15:45
Intensity-Interrogated Refractive Index Sensor Based on Exposed-Core Multicore Fiber Mach-Zehnder Interferometer, Shaoxiang Duan[1], Bo Liu[1], Hao Zhang[1], Xu Zhang[1], Haifeng Liu[1], Jixuan Wu[2], Yuan Yao[1]; [1]*Inst. of Modern Optics, Nankai Univ., China;* [2]*School of Electronics and Information Engineering, China.* A temperature-insensitive intensity-interrogated fiber sensor based on exposed-core multicore fiber for refractive index (RI) measurement is demonstrated by etching a seven-core fiber. The RI sensitivity of -287.252 dB/RIU is experimentally achieved.

Marriott
Salon I & II

CLEO: QELS-Fundamental Science

FF3M • Quantum Interactions in Nanophotonic Systems—Continued

FF3M.7 • 15:45
Goos-Hänchen shift in edge-reflections of two-dimensional surface polaritons, Ji-Hun Kang[2], Sheng Wang[1], Feng Wang[1]; [1]*Dept. of Physics, Univ. of California Berkeley, USA;* [2]*Dept. of Physics and Astronomy, Seoul National Univ., South Korea (the Republic of).* We introduce an analytic model describing the reflection of two-dimensional surface polaritons at an abrupt edge, and reveal that induced evanescent waves during the reflection leads to a Goos-Hänchen phase shift of π/4 in edge-reflections.

Marriott
Salon III

CLEO: Science & Innovations

SF3N • Modulators, Phase Arrays & Photodetectors—Continued

SF3N.7 • 15:45
Luneburg Lens for Wide-Angle Chip-Scale Optical Beam Steering, Samuel Kim[1], Jamison Sloan[1], Josué López[1], Dave Kharas[2], Jeffrey Herd[2], Suraj Bramhavar[2], Paul Juodawlkis[2], George Barbastathis[1], Steven Johnson[1], Sorace-Agaskar Cheryl[2], Marin Soljacic[1]; [1]*MIT, USA;* [2]*MIT Lincoln Lab, USA.* We present a design for a planar generalized Luneburg lens for use in a chip-scale optical beam steering device. The device has a theoretical in-plane field of view of 160° with no off-axis aberrations.

Marriott
Salon IV

SF3O • Saturable Absorber Materials & Chalcogenides—Continued

SF3O.8 • 15:45
Growth and Characterization of $PbGa_2GeSe_6$: A New Quaternary Chalcogenide Nonlinear Crystal for the Mid-IR, Valeriy V. Badikov[2], Dmitrii Badikov[2], Li Wang[1], Galina S. Shevyrdyaeva[2], Vladimir L. Panyutin[1], Anna A. Fintisova[2], Svetlana G. Sheina[2], Valentin Petrov[1]; [1]*Max Born Inst., Germany;* [2]*Kuban State Univ., Russia.* Non-centrosymmetric crystals of $PbGa_2GeSe_6$, grown in large sizes and with good optical quality, are used to characterize its linear (transmission, dispersion, and birefringence) and nonlinear (second order susceptibility) optical properties.